AIR&SPACE

Smithsonian · October/November 1989

Destination Mars:
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At break of day on a New South Wales sheepwalk, jackeroo Jim Capell and his trusty Kelpie muster the sheep that supply the wool for the Shetland Sweaters of Lands' End.

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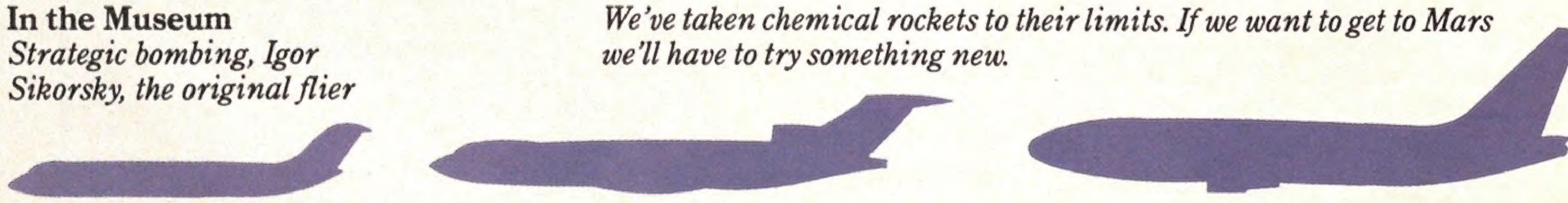

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Cover: *Artist Paul DiMare rendered a nuclear-powered rocket at the end of its long journey to Mars.*

Ambitions for a Thousand Years

Future generations looking back at our century a thousand years from now will marvel at the invention of the airplane and practical rocket flight, the revolution in military strategy and global travel, and the first exploratory voyages across the solar system, manned and unmanned.

To 30th-century men, women, and children, these feats will loom mythologically large. Comparisons will be made to the Egyptian master architects who gave us the pyramids and to the Golden Age of Greece with its wonderful legacy of sculpture.

Though historians no doubt will chronicle our times for centuries to come, history is not just books. Treasured objects passed down from generation to generation speak far more eloquently than words. We admire the Egyptians because we marvel at their pyramids. But the Colossus of Rhodes and the hanging gardens of Babylon, through many centuries also counted among the seven structural wonders of the world, are with us no more and have slipped into obscurity, in spite of historians and books.

If we are to convey the spirit of our times to future generations, we will have to preserve the airplanes and spacecraft that not only attest to our accomplishments but also embody that spirit. We want youngsters to continue to thrill at the sight of the Apollo 11 capsule that transported men on their first trip to the moon.

Given our ambition to preserve these symbols of our times, how can we see to it that we succeed in saving airplanes, satellites, and space probes for millennia to come? Left outdoors, metal rusts, rubber crumbles, and fabrics mildew. Birds begin to build nests in airplane fuselages, carpenter ants infest wooden parts, and trees sprout wherever seeds can root. No modern machine resists these onslaughts more than a few decades. To survive, it must be brought indoors. But that is only a first step, because unless vigilantly opposed through temperature, humidity, and ultraviolet radiation controls, corrosion and deterioration continue even indoors, albeit more slowly.

Preservation is a discipline of chemistry. Bleaching and other chemical changes brought about by radiation are studied by photochemists. Metal corrosion, often a form of oxidation, is researched by metallurgists and inorganic chemists; deterioration of rubbers and polymerization of lubricants are understood by organic chemists; and the retardation of fungal and insect attacks on fabrics and leathers lies in the province of biochemists. Specialists in these fields have learned a great deal, but this knowledge never finds its way into the know-how of museum curators. We need to build better bridges between chemical engineers and museum specialists.

With the introduction of each new aerospace material, new lines of research have to be pursued continually. Many of today's high-strength alloys have been around less than a decade; which atmospheric pollutants will most viciously corrode them? Nylon, as a structural material, has been around for five decades, Teflon three, carbon-fiber composites for only one; what do we know about their preservation? Though metal surfaces can be treated with corrosion inhibitors, how long do they stay protected?

While experience with aerospace materials dates back only decades or even less, our ambitions for preserving airplanes and spacecraft for future generations must take into account centuries, perhaps millennia. How should we deal with this mismatch between experience and need?

Many *Air & Space/Smithsonian* readers have a great expertise in the treatment and preservation of aerospace materials, perhaps not in the immediate context of airplanes but nevertheless with the same materials. If you have knowledge you could share with the Museum's staff, recipes for preventive maintenance, or any other suggestions that could help us in our mission to preserve, I would be grateful if you would write either me or our new conservator at the Museum, Edward McManus. Your advice could go far—as far as a thousand years.

—Martin Harwit is the director of the National Air and Space Museum.

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Letters

Deregulation Dissension

"The Deregulation Mess" by Paul Stephen Dempsey (August/September 1989) is highly misleading on a number of points, in part because Dempsey is highly selective about the statistics he cites to support his thesis. He states that "full fares have increased 156 percent since 1978—twice the rate of growth of the Consumer Price Index." He neglects to report that air fares overall have risen only half as fast as the CPI in the same time period, and that over the past few years approximately 90 percent of air travel has been on discount fares, which average some 60 percent off full fare.

He also states, without citing specific examples, that the "margin of safety" for air travel has shrunk over the past 10 years. If that is true, how does he explain the fact that the airlines have had a better safety record over the last decade than they did in the decade preceding deregulation?

Airline deregulation has been a success. It has resulted in enormous benefits to the public—increased productivity, more service to more places than ever before, and a vast array of price options and discounts.

Robert J. Aaronson
President, Air Transport Association of America
Washington, D.C.

I was appalled by "The Deregulation Mess." Dempsey completely fails to present any remotely logical argument for reinstatement of regulation.

First, the free market by definition charges whatever the market will bear. It either works or it doesn't. If a businessman can make a profit by paying a higher price to travel on short notice, and that in turn allows a student or retiree or family on vacation to travel at lower cost, where is the harm?

The provision of service to all towns must be paid for by someone. There is no free lunch. The service to an airport has to be paid for by the users or by a surcharge to those who fly to the larger cities and thus subsidize the unprofitable routes.

Since safety is better than ever, fares are cheaper, and the market is doing what it is supposed to, reinstating regulation would serve only to transfer the wealth created by legitimate effort into the hands of a non-productive profession—the lawyers.

Donald Sheldon
Pompano Beach, Florida

The only mess revealed by Professor Dempsey in "The Deregulation Mess" is that of his own logic.

In the first half of the essay he attempts to make the case that the airline "monopolists can charge whatever the market will bear." Then, in the second half, when addressing the safety issue, he claims: "Because profits are down, many carriers have not had sufficient resources to devote to maintenance or new equipment purchases."

If airlines enjoy a monopoly, why are profits down? And why are the airlines placing new-aircraft orders at record levels? In addition, Dempsey has not considered the possibility that the aging of the air fleet is due to the introduction of mature aircraft designs in the late 1970s; the service life of aircraft bought *en masse* would expire in the same time frame regardless of the existence of regulation.

No, Professor Dempsey, the time has not come to roll back deregulation, for to do so, according to the evidence, would be to increase the untimely-death rate of our fellow citizens.

John M. Logajan
Arden Hills, Minnesota

As a fellow professor of law I have been preaching the inevitable woes of deregulation both before and since the passage of the now-famous 1978 legislation, and nearly everything I envisioned—both good and bad—has come to pass. My greatest fear is that the airlines will ultimately go the way of the railroads and swallow or eliminate one another until eventually there is only one left—then the government will surely end up taking it over and we will have come full circle.

Ronald H. Moore
General Attorney, Eastern Air Lines
Miami, Florida

Air & Space/Smithsonian should be ashamed of itself for publishing such a non-factual article, and the University of Denver College of Law ought to be embarrassed that its name was included in the byline. Notwithstanding the weak accusations, the misrepresentations, and the overemotional tone of the article, deregulation has been a tremendous success. It has permitted airlines to reduce fares, improve safety, and earn profits that now enable them to place more orders for new jet aircraft than have been placed at any other time in the history of aviation.

Thomas G. Hiniker
Lexington, Massachusetts

Thanks for publishing "The Deregulation Mess." Dempsey succinctly explains the forces behind the perplexing and miserable experience of trying to travel by air in the United States these days. If there were some other way to go, consumers could use market forces to compel the airlines to improve fares and service. Our only hope is

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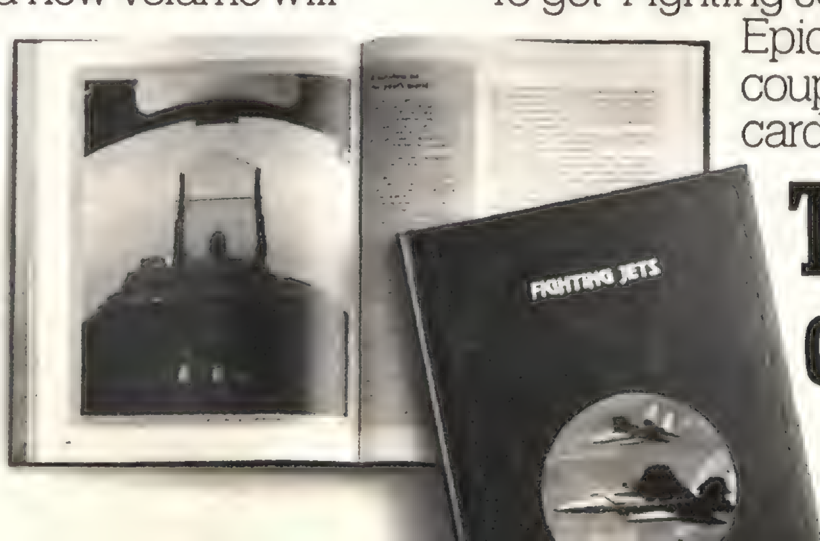

The Epic of Flight TIME LIFE BOOKS

that Dempsey's essay reflects a growing consensus on the need for extensive reform in contemporary commercial air travel practices.

Owen Andrews
Charlottesville, Virginia

"The Deregulation Mess" was disturbingly accurate. I am a pilot for a major airline and have had first-hand experience with much of what was written. The current system is an accident waiting to happen. The public must understand that they can change the system, but until they do, the Frank Lorenzos of this business will continue to have their way. I'm in total agreement with Mr. Dempsey: the time has come to roll back deregulation.

Name withheld upon request

Bugged by "Big"

I can appreciate Stephan Wilkinson's feeling overwhelmed by the Air Force C-5 ("Big," August/September 1989), but I don't believe this venerable giant deserves his negative portrayal.

First off, the article is in need of a correction. Mr. Wilkinson makes reference to "an original buy of 89 C-5A models, of which 85 survive." In fact, the original buy was 81 airplanes, of which 77 remain in service.

On a larger scale, let me point out that the Military Airlift Command could not accomplish its varied missions without the C-5. In peace or war, the C-5 delivers more cargo farther and faster than any aircraft in the free world. C-5s were the first resupply aircraft to arrive in Israel during the Seven Day War. More recently, C-5s carried UN peacekeeping forces to Africa and the Middle East. They flew oil drilling equipment to Alaska and relief supplies to Armenia. They carried oil drilling equipment to the Soviet Union in support of the INF treaty and even carried rescue equipment for two whales that were trapped in arctic ice.

The Galaxy plays a critical role in meeting this nation's defense requirements, a role Wilkinson unfortunately failed to find or to present to your readers.

Lt. Col. Phillip E. Lacombe
Deputy Director of Public Affairs,
Military Airlift Command
Scott Air Force Base, Illinois

Island Memories

"Pan Am's Pacific" by Henry Scammell (August/September 1989) took me back to my own days of living on the tiny coral atoll called Wake Island. My family moved there from the Bronx in June 1965 when my father accepted a position as a communications technician with RCA. I was 11 years old. We thought it would be a great experience to live on an island in the Pacific.

During our stay there we were surrounded by the sights and sounds of a different war—Vietnam. The island had a population of about 3,000 residents from all over. The Pacific route was well established by then, of course, but everyone on Wake knew how it all began. The original lagoon landing ramp for the Clipper was still there, respectfully being used as a boat/water-ski launch. A rusting gun turret and other relics from World War II were everyday sites. By the time your assignment was over, you'd had a thorough history lesson on World War II. It was a learning experience truly unlike any other.

One day, while a Pan Am crew was on a layover, a flight attendant sunning herself on the beach began pushing sand through her toes and suddenly felt something that was definitely not sand. She had uncovered a live bomb the Japanese had dropped 25 years earlier. In no time Air Force personnel safely moved and detonated the bomb out on the reef.

Had it not been for Pan Am's quest to open up the Pacific, I would not have had the chance to experience that wonderful little place or have met some very special people.

Barbara DeGennaro
North Brunswick, New Jersey

Worlds Apart

It is natural that the goals and tasks of the Soviet and the U.S. space programs are quite different. The two countries have always pursued different directions in aeronautics and space sciences. Currently, the U.S. is interested in establishing a permanent settlement on the moon, while the Soviet Union is concentrating its efforts on exploring Mars.

By collaborating on the joint Soyuz-Apollo mission in 1975, the two nations were able to put differences in technology aside and strive for a common goal. Specialists from both countries were able to coordinate efforts in developing compatible docking devices for their manned spacecraft. This mission was of historical significance because it was a technological breakthrough and became a symbol of

improving Soviet-U.S. relations.

The only other example that I can remember of our collaboration in this field since then involved some American equipment installed on Soviet space probes. The U.S. government has unilaterally rejected joint work on possible experimental flights involving the Soviet Salyut-type orbital station and the American space shuttle.

Now, with *perestroika, glasnost,* and the new warming in Soviet-U.S. relations, we would like to see a revival of the spirit of the first Soviet-American spaceflight. Many scientists are discussing the possibility of a joint Soviet-American mission to Mars. Many countries today benefit from the opportunities offered by the Soviet Union's space technologies. I wish that the United States could be among them.

Andrei Baidak
Novosti Press Agency
Moscow, U.S.S.R.

High Recognition Factor

My wife and I got quite a bang out of Edwards Park's "Reunion" (Above & Beyond, August/September 1989). When we'd discussed an upcoming reunion we used almost the exact words that appear in the dialogue between Mr. Parks and his wife at the beginning of the article.

Although I'm going to the reunion alone, my wife accompanied me to an earlier one in Colorado Springs last year. After 40-some years it was nice to remember and to be remembered. I'm sure your story hit home with a lot of veterans in their 70s and even 80s.

Louis H. Eisen
Oceanside, California

Politics, 1; Technology, 0

Ernest W. Maurer's concern that Apollo tooling and drawings had been destroyed (Letters, August/September 1989) reminded me of reports that the same fate had befallen Northrop's Flying Wing and the Blackbird SR-71. According to these reports, tooling for both was ordered destroyed by politicians who did not want them competing with more favored designs.

With the cost of the B-2 raising controversy, one can be forgiven for wondering how much cheaper the airplane would have been if we had not trashed the Flying Wing. No administration has a right to destroy bought-and-paid-for engineering just to advance another pet project. If someone should die relearning the lessons

of Apollo, whoever ordered destruction of the original works should be prosecuted for manslaughter.

Walter E. Wallis
Palo Alto, California

C-2 ID

The Calendar section of the August/September 1989 issue states that in 1922 the Army airship C-4 detoured over Cincinnati, Ohio, during a flight to the West Coast so that Major H.A. Strauss could drop flowers to his mother. The airship was the Army C-2, not the C-4. The C-2 was the first lighter-than-air craft to fly cross-country. It remained on the West Coast until October 10, 1922.

James R. Shock
Warren, Michigan

The Sky Is Falling

I was quite angry to learn from Greg Freiherr's article "What Goes Up . . . " (August/September 1989) that the military can step in and decide when their secret satellites must go up even though a very large, expensive satellite that has been in orbit for years is about to fall out of the sky, endangering the lives of who knows how many people.

NASA should take responsibility for protecting people from its falling satellites, and the military should learn that the lives of innocent people are more important than satellites that only bring attention to war.

Greg Sismilich
Carrollton, Texas

Thank you for publishing Greg Freiherr's excellent and informative article on the Long-Duration Exposure Facility. I was moved to send some letters to Washington and was able to convince many of my space-loving friends to do the same. I only hope we're not too late.

Many of the people I spoke to had no knowledge of LDEF. I wish the general media were more responsible in keeping the public informed on scientific studies and exploration, especially an issue as crucial as LDEF.

Pamela B. Foard
Brookfield, Wisconsin

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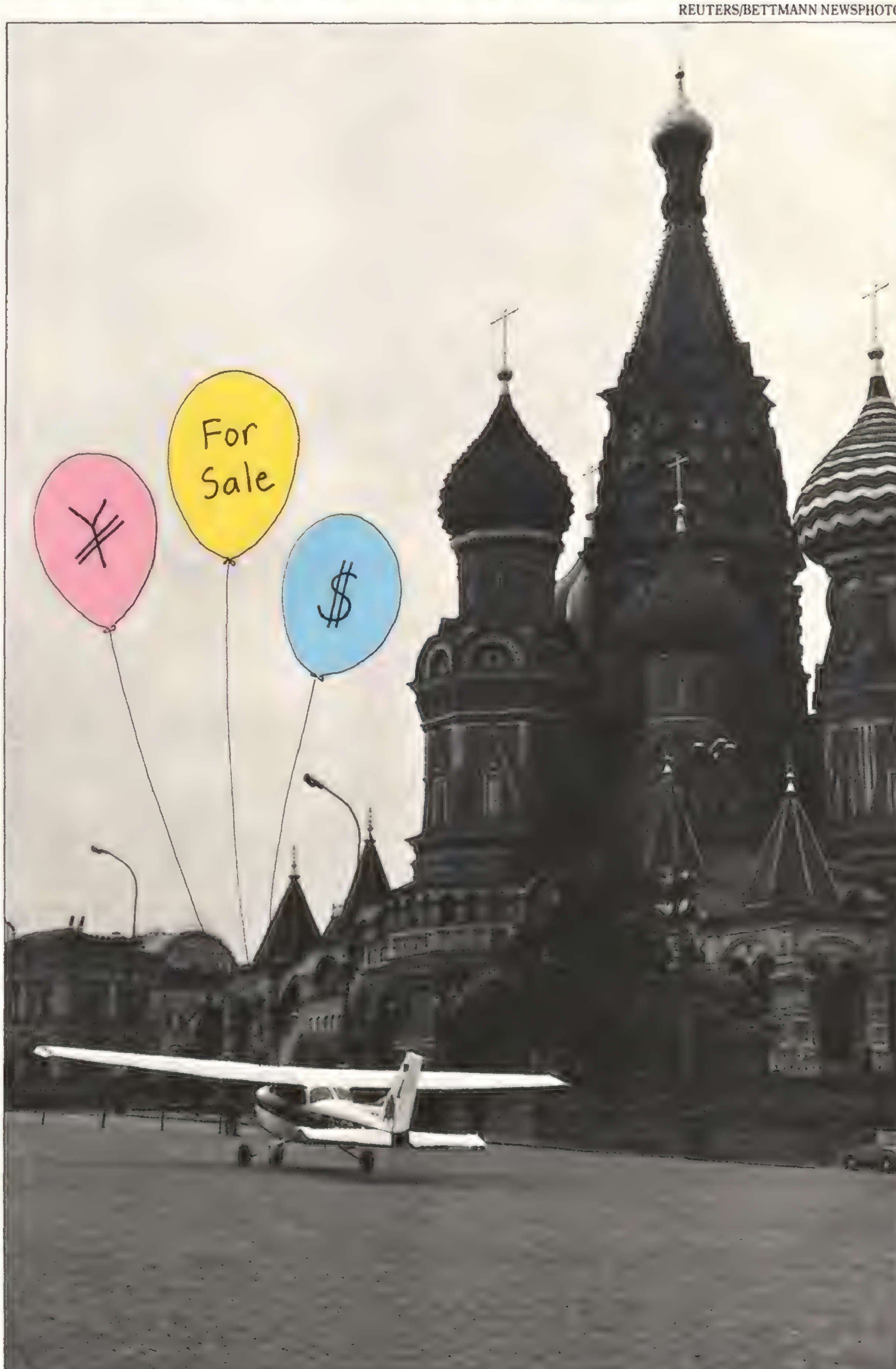
The Loneliness of the Long-Distance Cessna

REUTERS/BETTMANN NEWSPHOTOS



When 19-year-old Mathias Rust rented a Cessna 172, flew from Helsinki to Moscow, and landed near Red Square in May 1987, he probably never considered the possibility that the airplane might become a coveted international *objet d'art.* Just as well, because it didn't. Nor did Rust achieve a similar elevated status: upon his release by the Soviets 14 months later, West Germany received him as more harebrained than hero. Nonetheless, financial gamblers are still cashing in on the aircraft's notoriety.

A month after the flight, a Munich perfume distributor bought the single-engine airplane—valued at about $55,000—from the Hamburg flying club that rented it out. Wolfgang Neumann paid $94,000 and said he planned to use the aircraft to advertise Azuma Royale's fragrances, as well as lease it to sponsors of other products.

Alas, politics intervened. At a time when East-West relations were improving, Rust's flight proved a diplomatic embarrassment. In May 1988 Neumann told the *Washington Post* that he had trouble getting permission to exhibit the airplane because no one wanted to offend Moscow, which was chagrined that its air defense network could be snookered by a mere Cessna. Further, Bonn government officials feared that such publicity might diminish Rust's prospects for early release from a four-year sentence for "malicious hooliganism."

According to Neumann, the West German foreign ministry in particular was less than enthused, although a ministry official said the agency did not actively intervene. In the United States, Cessna refused to sponsor the display of the aircraft at airshows—a new *Spirit of St. Louis* it wasn't. Income from a later exhibit in France netted Neumann only $47,000.

"People kept saying they wanted to exhibit the plane, and then they would back off," said Neumann. "I got so mad about it that I just decided to sell it."

Neumann advertised in the Paris-based *International Herald Tribune* and the *New York Times* in May 1988. The ads

clearly aimed at selling the sizzle instead of the steak: "Most Famous Airplane To Sell: Do you want to own the only plane that landed on the RED SQUARE/MOSCOW?" Despite some nibbles, including one from an Australian amusement park, the answer apparently was "not especially"—particularly for the asking price of $250,000.

Last June, the Cessna appeared in *Trade-A-Plane*, advertised as "Now on sale: The plane that landed on the Red Square" with a phone number in Kobe, Japan. The seller, Rouhollah Momtazi, says he bought it "for over $100,000" from a collector in West Germany who had taken it off Neumann's hands. "My requesting price would be around $200,000," Momtazi writes, which includes "many interesting photos and stories written by Matheus [*sic*] Rust and others." The disassembled airplane is sitting in a box at a Tokyo airport while Momtazi sorts through the numerous offers he says he's received.

—*Fred Reed*

Update

AMROC Loss, Gain

American Rocket Company president and co-founder George A. Koopman was killed on July 19 in an automobile accident near Edwards Air Force Base in California ("The California Rocket Race," December 1987/January 1988). When this issue went to press, AMROC's first suborbital launch was scheduled to loft two payloads on September 20 from Vandenberg Air Force Base in California.

Cheaper by the Dozens

PAUL SALMON

Of the 431 airports in Oregon, 35 are owned by the state. Strapped for funds to run these abandoned military bases and flagging municipal fields, Oregon is giving them away.

The town of Myrtle Creek has already snatched one up. "It'll never be Myrtle Creek International," says mayor Bob Cotterell, a former B-17 and Air Force test pilot, but "I'm pleased to have an airport. I always wanted one."

That kind of proprietary interest—even if it is tongue-in-cheek—is exactly what the Oregon Transportation Department's aeronautics division is looking for. The Federal Aviation Administration and state requirements for acquiring an airport are simple: it must be operated for public use for 20 years. "That's about it," says community aviation services manager Fred Mills. "No money changes hands. We will deed the airport over to them."

State airport manager Tom Robertson would welcome the dismantling of his 35-airport empire (only Alaska owns more). The state agency is not eligible for lottery or development funds to maintain or improve the airports, "but communities are," he says. Both he and Mills say the state's 3,849 general aviation pilots, non-fliers, and entire towns will benefit from the giveaway.

The free airports range from Aurora State with some 200 aircraft, a 4,100-foot runway, and more than 71,000 takeoffs and landings a year to—well, almost nothing. "We've got some ex-military strips left from World War II out in the eastern part of the state," says Robertson. "Six thousand feet of runway but nobody within 15 to 20 miles. We do maybe $200 or $300 worth of maintenance a year to them—a new windsock, maybe cut a little sagebrush. Once in a while they do save somebody." And, he adds, "It gives the local rancher and cattle buyer some place to meet."

Myrtle Creek's Cotterell and city administrator Joe Hannan have a loftier vision for their piece of real estate. After acquiring the 2,600-foot runway and 88 acres from the state last May, they recruited an aircraft fuel and repair business and now dream of putting in a nine-hole golf course around the airport. "Fly in and go play golf and fly out—that has real potential for us," says Hannan. Another 15 acres zoned for industrial use offer more mundane opportunities. "I'd characterize it as a diamond in the rough," he says.

Marion County administrative officer Ken Roudybush has a strictly utilitarian vision for Aurora State Airport. Along with the aviation benefits, he says, "it would be nice to have a great big landfill." Marion County burns its municipal waste, and down the road Roudybush envisions a combination landfill and airport—"two places that no one wants to live near," he says. "A real compatible land use if we owned all that."

—*Bob McCafferty*

Update

Airshow Guide

The International Council of Airshows has formed the Flight Line Club to keep airshow enthusiasts abreast of events and performers. An ICAS spectator-member will receive information on some 350 U.S. shows, the association's magazine, and, of course, a T-shirt. Call (517) 782-4466.

Chicken Little Was Right

Bursts of radiation and high-energy particles from the current spate of solar pyrotechnics are heating up the tenuous outer layers of Earth's atmosphere, causing it to expand and creating a slight but lethal drag on low-orbiting satellites. Over time, the denser atmosphere slows them down enough so that gravity can pull them back to Earth.

The most recent orbital victim, succumbing last July 8, was an Apollo

command and service module shell jettisoned from a 1965 Saturn launch of the meteoroid-counting satellite Pegasus 2. NASA estimated that up to 3,000 pounds of the six-ton boilerplate would survive reentry, and that the chances of it causing a casualty were about six in 10,000. Two other Apollo boilerplate reentries, in August 1969 and July 1985, occurred without incident, as did this one.

Solar Max, the heroic satellite sent up in 1980 to study the last solar outburst, is now doomed by the current one. NASA expects 11 large pieces of Solar Max, some weighing 100 to 250 pounds, to survive reentry in early December, along with numerous small chunks. The chances of these causing a casualty is estimated at about 2.5 in 10,000, about a hundredth that calculated for the 1979 Skylab reentry, which spread debris over Australia. And hot on the heels of Solar Max is the Long-Duration Exposure Facility, an 11-ton satellite launched in 1984 and due to fall next January—unless NASA can get a shuttle up by mid-December to retrieve it.

One of the major solar-powered worries at NASA, however, is one that hasn't yet left the ground: the Hubble Space Telescope. Delayed by the *Challenger* loss, the HST has been queued up for a shuttle berth since 1986. Now scheduled for a March 1990 launch, the $1.5 billion observatory will be orbiting in the hottest space environment since the solar maximum of 1958. "We are launching into the teeth of the storm, so to speak," says Marshall Space Flight Center project engineer Bill Murray.

According to Murray, NASA is concerned about maintaining control with the energy provided by the HST's reaction wheels, the momentum devices that point the telescope. Officials also fear that atmospheric drag could erode the orbit so rapidly that a quick reboost to a higher orbit would be needed. Although the telescope was designed with occasional reboosts in mind (Soundings, August/September), the design assumed five years of operation before one would be needed.

Unusually high levels of solar activity are predicted as the current 11-year cycle accelerates toward a maximum. This peak is expected to be reached in February 1990 but could be later—and higher—than predicted. And if this cycle follows the example of its predecessor, there could be several peaks, many months apart.

According to Murray, the forecast is for activity of 238 solar flux units—units of energy per unit of surface area—with a possible range of 205 to 290. The higher the solar flux units, the higher the atmospheric density, and the higher the

PAUL SALMON

HST must orbit. "We need to be about 10 nautical miles higher in our initial insertion into orbit," he says. "Ordinarily we would need to insert at 320 nautical miles circular to get four years' orbit. Now we want 330 nautical miles circular to get in five years without a reboost."

The strategy for flying the HST into the solar gale is a kind of cascade of restrictions. Lower-than-predicted activity would permit NASA to orbit the telescope pretty much as planned. At levels above 250 solar flux units, they would probably launch but restrict pointing the telescope until atmospheric density declined enough to permit full control of the spacecraft. Much above 250, Murray says, and they would have to begin trading—planning for a reboost in less than five years, or further restricting aiming the telescope.

SCIENCE/SCOPE®

A 30-foot high commercial communications satellite is providing communications services to Japan. JCSAT 1, built by Hughes Aircraft Company for Japan Communications Satellite Company (JCSAT), is the largest Hughes-built commercial satellite launched to date. The HS 393 satellite, a larger and more powerful version of Hughes' HS 376 satellite, carries 32 transponders, each capable of transmitting one television channel, a stream of 45 million bits of data per second, or more than 250 telephone conversations. The telescoping solar arrays onboard the satellite will generate about 2,200 watts of electrical energy and permit JCSAT 1 to transmit to ground antennas as small as four feet in diameter.

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Communications satellites with more than twice the transmitting power of earlier models reduce the size and cost of earth receiving stations. The Ku-band HS 376 satellites, designed and built by Hughes, transmit with approximately 20 watts per transponder. At this power, earth station antennas as small as four to six feet in diameter, small enough to be mounted on rooftops, walls, or poles, can be used for both transmitting and receiving satellite signals. By comparison, lower power, C-band satellites require antennas six to ten feet in diameter for receiving capability. The high-power satellites are part of Hughes' Very Small Aperture Terminal network, which provides end-to-end satellite communications for data networking and videoconferencing.

New computer-controlled milling machines automatically correct for tool wear and other machine misadjustments. By operating up to 10 times faster than conventional equipment, these new Hughes machines make continuous off-line inspection of machined parts prohibitively expensive. So before and after each tool is used, an internal contact probe measurement system checks the dimensions of a trial cut. If the cut does not meet specifications, computer software in the controller adjusts the tool to bring it back into tolerance. These machines are used to manufacture radar system parts whose thousands of dimensions must be held to tolerances of three thousandths to .5 thousandths of an inch.

Hughes Technical Services Company (HTSC™), a subsidiary of Hughes Aircraft Company, is rapidly expanding its contractor operations and logistics support to meet individual and customer program requirements. Upcoming military contracts to be supported by HTSC include simulators for the T-45 Goshawk, Fleet ASW Team Training and Landing Craft Air Cushion. HTSC presently needs engineers, programmers and field service technicians with experience in simulation in order to keep pace with new contract requirements. Qualified candidates may send resumes to: Hughes Technical Services Company, Trainer Support, Dept. S4, P.O. Box 90962, Long Beach, CA 90809. Equal opportunity employer. Proof of U.S. citizenship required.

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In one worst-case forecast, atmospheric density would increase enough to bring the HST back to Earth in nine months unless a reboost could be scheduled. At those improbably high levels of solar activity, Murray says, NASA would have to avoid that fate by delaying the launch, forfeiting its place in the shuttle queue, and going back to what it has been doing for the past several years: waiting.

—*Carl A. Posey*

Update

Airborne Archeology

Color infrared photographs of prehistoric gardens, taken on a 1987 NASA-Lockheed flight over New Mexico's Galisteo Basin, show that the Pueblo Indians who built the plots were agriculturally advanced ("Looking Down on History," August/September 1988). The 65 images, taken from a Learjet and recently analyzed at the University of Colorado at Boulder, reveal that the Anasazi had used pebble mulch to retain soil moisture. A university researcher has suggested that this practice might help today's drought-prone areas.

Lost and Found

Henry Sakaida is an aviation historian who has a thing about mysteries. "They bug the hell out of me," he says. Which is why he doesn't read whodunits. Instead, he solves them. He's probably the world's foremost detective specializing in an obscure aspect of military lore: determining precisely who shot down whom in World War II. Since 1979 Sakaida has investigated more than 30 combat engagements and has managed to identify the participants in about half of them.

Sakaida, 37, is a Los Angeles nurseryman who has never flown an airplane, much less a World War II fighter. His lifelong interest in that era has always centered on the men rather than the machines. Being fluent in Japanese gained him entry to the tight-knit world of former Zero pilots. While touring Japan in 1975, he was asked by one of these veterans to locate the American who had shot him down over Guam during the Marianas Turkey Shoot in 1944. Although Sakaida failed—too many Zeros were destroyed that day to

PAUL SALMON

enable a positive identification—he was hooked. Four years later, more skilled in the nuances of the chase—mostly done by phone and mail—he identified U.S. Army Air Forces first lieutenant James J. Finnegan, flying a P-47, as the man who had shot up Luftwaffe major general Adolf Galland's Me 262 and wounded its pilot in May 1945.

Like most detectives, Sakaida has his share of frustrating cases. One dragged on for seven years. Then there was the Japanese flier who had come across a badly damaged Hellcat but said he declined to attack because the pilot looked so forlorn. Sakaida managed to identify the American pilot but also learned that he had later drowned after ditching in the Pacific. "It's depressing," Sakaida says. "You do all this work and you find out that the guy died 42 years ago." Sometimes he discovers the identity of a pilot only to learn that he doesn't want to be found. But mostly he says he's a welcome messenger. "It's a big question mark to them," Sakaida explains. "I try to resolve it so that they'll finally know what really happened."

Sakaida says his most satisfying cases are those that culminate in a meeting between former adversaries. A few years ago he reunited Zero pilot Saburo Sakai and Dauntless dive-bomber gunner Harold L. Jones. The two had originally crossed paths off Tulagi Island in the Solomons on August 7, 1942, and it's a miracle either lived to tell the tale: during the skirmish Jones' Dauntless was punctured with 232 holes and Sakai was blinded in one eye.

Some 40 years later Sakai and Jones met at Sakaida's father's home in Southern California. "To see those two guys who had shot at each other 40-odd years ago shaking hands and slapping each other on the back gave me a deep-down good feeling in my heart," Sakaida says. "I felt like I really accomplished something worthwhile."

"This is like a dream," Sakai had said. "Henry deserves all the credit," said Jones. "He worked his fanny off."

Of the five cases Sakaida is now investigating, the most promising was prompted by former P-51 pilot Edward Bollen's inquiry about the Japanese Oscar he shot down in 1945. Because the pertinent Japanese records had been destroyed, Sakaida enlisted a Japanese historian, who learned the name of a pilot wounded under circumstances that fit Bollen's scenario. But there was a discrepancy in the dates. Backtracking through the files at the Air Force Historical Research Center at Maxwell Air Force Base in Alabama, Sakaida found that the

Japanese pilot had been shot down not by Bollen but by two other P-51 pilots. Bollen's case was at a dead end, but Sakaida is now hot on the trail of the two U.S. fliers. He is checking with veterans' organizations and will run ads in special-interest publications to locate them. "If they're still alive," he says, "I'll find them."

—*Preston Lerner*

Update

NASA's Interior Designs

NASA Ames Research Center's habitability research team, led by Yvonne Clearwater (Soundings, April/May 1987), was recently awarded the American Society of Interior Design's 1989 Human Environment award. For the past five years the team of 40 researchers has been studying space station interior designs that will improve astronaut productivity and psychological health on long missions. Recommendations include painting ceilings lighter than walls to reduce disorientation and supplementing windows with photographs to provide numerous "views."

DENNIS DI CICCO AND LEIF ROBINSON/SKY & TELESCOPE

The July 2 occultation of the star 28 Sagittarii *by Saturn gave astronomers a rare chance to study the density and composition of the planet's rings and atmosphere. The star's light repeatedly dimmed and disappeared as ice particles and debris obscured it. Here, it blazes through the Cassini division, a wide gap in Saturn's rings.*

AIRSHIP INTERNATIONAL LTD.

Update

Old Guns, New Scores

New York Air National Guard pilots moving up to F-16s modified for close air support are racking up exceptionally high scores on the firing range ("Old Gun," August/September 1988). Most F-16 pilots score around 30 out of 100 their first time on the range, but the 174th Tactical Fighter Wing pilots, who previously flew A-10 Thunderbolts, are scoring as high as 50.

Donald Trump's next planned acquisition is a mammoth blimp that will dwarf the classic Goodyear model. The 12-passenger blimp, equipped with leather seats, gold-plated hardware, and a gourmet galley, will be offered on loan to the customs agency and Coast Guard as a surveillance platform. Its primary duty, however, will be to promote its owner's real estate holdings.

Anniversaries . . .

1909
October 27 Mrs. Ralph Van Deman becomes the first woman airplane passenger in the United States when Wilbur Wright takes her up for a four-minute flight from College Park, Maryland.

NASM

Mrs. Van Deman's friendship with Wilbur Wright's sister led to a historic flight.

1921
October 4 Madeline Davis, a 23-year-old stunt flier and wingwalker, is killed during an attempt to board a low-flying airplane from a car. As both vehicles maintained a speed of 50 mph, Davis caught a rope ladder hanging from the airplane and dangled momentarily before falling 15 feet and fracturing her skull. Shortly before her death, Davis had told Ruth Law, who ran a flying circus, "There is nothing on land or in the air that I am afraid of. If I can learn to take the leap from an automobile to an airplane I ought to be a big attraction for your company."

1926
October 23 Prompted by complaints from pedestrians, police in Berlin, Germany, halt a local chocolate factory's aerial advertisements. For several Sundays, the company had sent up two pilots to pelt crowds with hard chocolates wrapped in heavy foil.

1927
October 1 Two men confess to New York City police that their love of flying drove them to commit over 100 burglaries. Philip Peffer, 24, and Philip Bogitch, 18, then complained of having girlfriends who also loved to fly. "Just as soon as they hit the ground, they wanted to go up on another ride," said Peffer. "We blow our money in the daytime on planes as fast as we could steal it at night."

1929
November 27 Harold Brown, a pilot conducting sightseeing flights from Whittier, California, prevents a passenger from committing suicide. At 2,000 feet Brown noticed Earl Endicott trying to leap from the cockpit and quickly side-slipped the airplane, throwing Endicott back into his seat. Once more Endicott attempted to jump and Brown responded with a vertical bank. After landing, Brown took his passenger to the police. Endicott, 22, had come to Whittier from Glendale, Arizona, to seek employment.

1940
October 26 North American's NA-73X, the prototype for the P-51 Mustang fighter, makes a 22-minute maiden flight from Mines Field in Los Angeles. The P-51 was used extensively by U.S. and British forces during World War II. The third NA-73X test pilot, R.C. Chilton, later said that the aircraft "had established the trend for what I believe was the finest propeller-driven fighter ever built by any country."

1962
November 19 Dulles International Airport, built on 10,000 acres of farmland in northern Virginia, opens for business. Dulles was the first airport to use mobile lounges, which eliminate long walks for passengers by transporting them from the terminal gates to the aircraft.

DEPARTMENT OF TRANSPORTATION

Eero Saarinen designed Dulles airport's glass-walled terminal.

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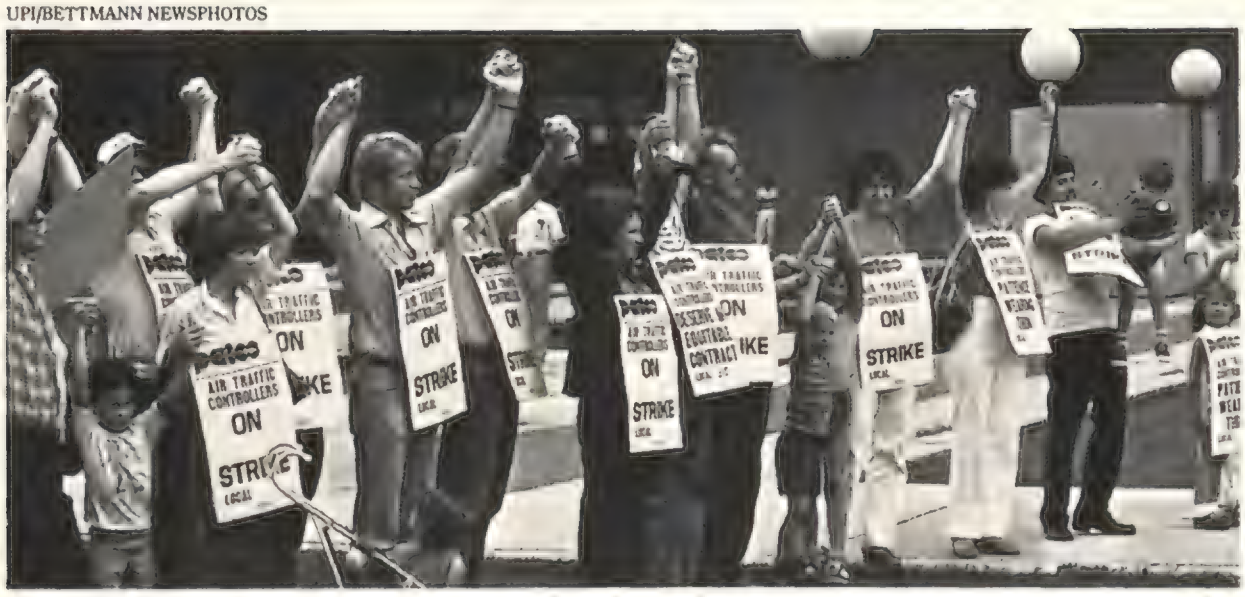


Grasping hands in solidarity, strikers ignored Reagan's back-to-work deadline.

1981

October 22 After beginning a strike on August 3, the Professional Air Traffic Controllers Organization is decertified by the Federal Labor Relations Authority. Controllers walked out in an effort to gain salary increases, a shortened work week, and early retirement. Reminding them of the illegality of striking against the federal government, President Reagan gave PATCO members until August 5 to get back to work. By the time all termination notices were mailed, 11,438 employees had been fired. In the first few days of the strike, airlines cut back operations by as much as 40 percent, but by the end of August they were running 75 percent of normally scheduled flights, with ATC positions filled by supervisors and controllers on loan from the military.

1988

October 26 A British Airways 747 flies 7,915 miles from Tokyo to London with a single passenger. A Japanese woman made the 13-hour flight alone when the jumbo jet was delayed by technical problems at Tokyo. Nearly 200 other passengers chose to take alternate flights, leaving the woman with her pick of 353 seats and six movies.

November 10 The Air Force publicly acknowledges the existence of the Lockheed F-117A Stealth fighter and releases a long-awaited photograph. "It is a mature system, and it's time to go public with it. We have to start daytime flying," said Pentagon spokesman Dan Howard, who confirmed that the aircraft first flew in 1981 and became operational in 1983. Last spring, the Air Force stepped up the number of daytime flights for the 4450th Tactical Group's 52 F-117As, which are based at Tonopah Test Range Airfield in Nevada. The aircraft, which have been spotted over Monterey, California, and south of the Mojave Desert, are seen regularly in Nevada. In all of the sightings, observers note a high-pitched whine as the aircraft approaches. Contrary to expectations, the F-117A's stealth comes not from a fuselage of rounded contours but

USAF

Pilots control the angular F-117A with a fly-by-wire system.

one of flat surfaces that reflect energy away at angles, yielding a low radar cross-section. Lockheed designed the aircraft to penetrate enemy territory and strike selected targets by evading radar and infrared detection.

... and Events

Through October 15
"Black Wings: The American Black in Aviation." Smithsonian Traveling Exhibition. At Western Aerospace Museum, Oakland, CA, (415) 638-7100.

"Exploring the Planets." Smithsonian Traveling Exhibition. At Heritage-Hjemkomst Interpretive Center, Moorhead, MN, (218) 233-5604.

"The View From Space: American Astronaut Photography, 1962–72." Smithsonian Traveling Exhibition. At Museum of Science and Industry, Chicago, IL, (312) 684-1414.

October 5
"Desert Landforms of Earth and Mars." Lecture at Anchorage Museum of History and Art, Anchorage, AK. Smithsonian National Associates, (202) 357-1350.

October 7 & 8
Airfest Arizona '89, the largest civilian airshow in the Southwest. At Love Field, Prescott, AZ, (602) 776-3704.

Flanders Valley Experimental Aircraft Association Fly-In. Best built pedal plane contest. At Sussex Airport, Sussex, NJ, (201) 702-9719.

October 13
"Living and Working in Space." Lecture at New York State Museum, Albany. Smithsonian National Associates, (202) 357-1350.

October 14–November 12
"Steichen and His Men: A Photographic Portrait of World War II." Smithsonian Traveling Exhibition. At Boston National Historical Park, Boston, MA, (617) 242-5645.

October 28
"Wings Over the Ocean." Lecture at Old Dominion University, Norfolk, VA. Smithsonian National Associates, (202) 357-1350.

November 1–December 31
"Space: The Next Generation." A mock space station is the cornerstone for this temporary exhibit. At Children's Museum, Indianapolis, IN, (317) 924-5431.

November 4 & 5
Miami Air Show. Harrier jump jet, vintage aircraft, Blue Angels, and wingwalkers. At Building 210, Opa Locka Airport, Miami, FL, (305) 685-7025.

November 4–30
"Visions of Flight: A Retrospective From the NASA Art Collection." Smithsonian Traveling Exhibition. At Indianapolis Art League, Indianapolis, IN, (317) 255-2464.

November 4–December 3
"Black Wings: The American Black in Aviation." Smithsonian Traveling Exhibition. At McMillan Memorial Library, Wisconsin Rapids, WI, (715) 423-1040.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Events will be listed as space allows.*

—Diane Tedeschi

The Legacy of Strategic Bombing

USAF

The Boeing B-17 Flying Fortress was used extensively in both World War II theaters.

"There were sounds like giant footsteps above. Those were sticks of high-explosive bombs. The giants walked and walked." Like the protagonist of his novel *Slaughterhouse Five,* Kurt Vonnegut Jr. experienced the Allied raid on the German city of Dresden firsthand as an American prisoner of war. The fire-bombing, which killed anywhere from 50,000 to 100,000 people, was designed to crush the morale of Germany and hasten the end of the war. But the Allied attempt to bring the enemy to its knees by bombing its cultural capital troubled even those desperate for victory. Winston Churchill called for a review of "the question of bombing of German cities simply for the sake of increasing terror, though under other pretext."

"The Legacy of Strategic Bombing," a lecture, symposium, and film series organized by the National Air and Space Museum, picks up the debate. Some 50 participants, including Vonnegut, will take part in the 14-part series, which started last month and runs through December 1990. Its goal is to examine the history and legacy of strategic bombing, and it includes among its speakers many who shaped the history of air power.

The participants bring a wide range of experience to the series. Philip Morrison, a physicist on the Manhattan Project, was part of a scientific team that visited Hiroshima after the first atomic bomb fell. Freeman Dyson worked for the evaluation team of the Royal Air Force Bomber Command. Lord Solly Zuckerman served in the British Bombing Survey Unit. John Kenneth Galbraith, Paul Nitze, and George Ball all served on the U.S. Strategic Bombing Survey. And in addition to government leaders, scientists, and historians, the participants include Harold Stearns, a B-17 gunner, Heinz Knoke, a Luftwaffe fighter pilot, and his wife Lilo.

The impetus for the series is an exhibit on strategic bombing that the Museum is planning for its future extension. Originally Museum curators planned to convene a panel to educate themselves for the upcoming exhibit. But the project kept growing, and the Museum decided to open some of the symposium sessions to the public and to include both a lecture and a film series. (Approximately half of the symposia remain invitation only.) Included are such classic films as *Victory Through Air Power, On the Beach,* and *Dr. Strangelove,* as well as short documentaries from the National Archives.

A book based on the series is planned, and video recordings will provide material for the future exhibit. According to the organizers, the series has already generated a lot of excitement in the academic community. Richard Kohn, chief of the Office of Air Force History, isn't surprised. "I think it will attract a great deal of attention because the overall quality of speakers is very high," he says.

Realizing how controversial the subject is, the organizers have taken pains to balance the presentations. Although 50 years have passed since the beginning of World War II, questions about the value of strategic bombing remain highly controversial. The debate largely centers on issues of morality and military utility. During the war the Americans and the British were divided over the question of whether precision bombing of industrial targets was more effective than area bombing aimed at the morale of the enemy. The geographic isolation of the United States allowed U.S. military strategists to engage in more abstract analysis, while the British had to live with the fear of reprisal.

The debate over strategic bombing also has provocative parallels with the current debate on the nuclear arms race. "It really does compare in a very interesting way to how the current generation worries about nuclear warfare," says Tami Davis Biddle, a Smithsonian Fellow from Yale University. "People were very, very afraid of bombs," she says, because between the world wars conventional bombs became increasingly fearsome.

In both format and theme, "The Legacy of Strategic Bombing" represents something of a departure for the Museum. "In the past the Museum has celebrated technology and looked at it uncritically," says Gregg Herken, chairman of the Museum's space history department, "and we want to look at it from a new perspective."

JAMES DIETZ

"Breakthrough Over Kiev" depicts Sikorsky's 1914 record flight from St. Petersburg.

The Sikorsky Century

At the height of the Korean War, Igor Sikorsky began to receive visits from helicopter pilots back from the front. After the pilots finished paying their respects to the man who had developed their aircraft, they would ask to see the fedora that Sikorsky had worn while he was testing his famed VS-300 helicopter. Sikorsky was amused as each pilot bashfully tried on his hat. The visits began to occur with increasing frequency, and Sikorsky eventually learned that his fedora had a reputation as a good luck charm among the troops in Korea. The pilots were paying homage to the designer and his hat to ensure a safe landing.

Igor Ivanovich Sikorsky would have been 100 years old this year. To commemorate this anniversary, as well as the 50th anniversary of the maiden flight of his VS-300, the Museum will open an exhibit on the pioneer airman in November.

It would be hard to exaggerate the breadth of Sikorsky's career. When he was 24 czar Nicholas II gave him a gold watch for his services to his country. In 1953 he was on the cover of *Time* magazine as the father of the Rotor Age. In between he built record-breaking seaplanes that graced the Golden Age of Aviation. "He's certainly worthy of any hagiography people attempt to write about him," says Von Hardesty, one of the exhibit's curators.

The excitement surrounding the double anniversary is not limited to the United States. Thanks to *glasnost*, the Soviet Union has been reclaiming Sikorsky as a native son. Hardesty and Sergei Sikorsky, the inventor's son, met "undisguised pride" while doing research in Moscow. "Dad was a very modest person," says his son. "But privately he would be very pleased and certainly very honored."

The gold watch, which along with the legendary fedora is part of the exhibit, shows the esteem Sikorsky enjoyed in the Russia of another era. Born in Kiev, Sikorsky built his first helicopter in 1909. "It was a good helicopter," he would later say, "but it did not fly." He shelved vertical flight temporarily in favor of airplanes and designed the first four-engine model. In a few years residents of St. Petersburg were regularly thrilled by the sight of his *Grand* and, later, his *Il'ya Muromets*, flying over the Ukrainian city.

The Bolshevik Revolution forced Sikorsky to flee the country. In 1919 he arrived in New York City, where Sergei Rachmaninoff, the Russian pianist, gave him $5,000 to help him get started. By 1927 Sikorsky was working with the premier World War I ace, René Fonck, in an attempt to fly from New York to Paris.

Though Charles Lindbergh made the flight first, Sikorsky and the U.S. aviator later became close friends and worked together on the flying boats that enjoyed great popularity for several decades. The decline of the flying boats in the late 1930s turned Sikorsky's attention back to vertical flight.

The Museum exhibit's centerpiece is the VS-300—the first successful single-main-rotor/single-tail-rotor helicopter. Paul E. Garber, historian emeritus and Ramsey Fellow at the Museum, had an opportunity to fly with Sikorsky on the VS-300. As a U.S. Navy commander, Garber visited Sikorsky at his Stratford, Connecticut factory in 1943. "I had my hand on the frame and then he . . . raised me, oh, about maybe eight or ten feet, but that was a wonderful experience."

In 1953, when Sikorsky made the cover of *Time*, readers were instructed how to pronounce "*hell*-icopter." Though the heliports described in the piece are still in the future, Sergei Sikorsky says that without question the helicopter was the accomplishment his father was most proud of, not only for its unique role in aviation but "also as an instrument for saving lives." Says his son, "He was enchanted with the idea of the helicopter from the beginning."

MARK AVINO/NASM

Vice President Quayle, President Bush, and Apollo 11 astronauts Neil Armstrong, Buzz Aldrin, and Michael Collins visited the Museum last July on the 20th anniversary of the first moon landing.

CAROLINE SHEEN

Michael Robinson demonstrates the original flying machine for Martin Harwit.

The Original Flying Machine

"I'm an airplane nut," Michael Robinson says. This admission, while not unusual in itself, has new implications coming from the director of the National Zoological Park. It certainly accounts for the models in his office: a Focke-Wulf Fw 190 A-6, a Supermarine Spitfire Mark XIV, and an Avro Vulcan. It also explains how the Museum happened to acquire a life-size model of a prehistoric dragonfly.

Nearly 275 million years before the Wright brothers, *Meganeura moinyi*—the ancestor of today's dragonfly—ruled the sky. "It was huge," says Robinson, "I mean a 28-inch wingspan." When he decided to create a model of this insect, the first animal to conquer the air, and hang it in the National Zoo's invertebrate exhibit, Robinson started thinking about other flying machines. When he told Martin Harwit about the model, the Museum's director agreed it was a good idea for the Museum to display the *original* flying machine.

The model is based on Paleozoic fossils from Oklahoma and Kansas initially described by Frank Carpenter, a specialist in fossilized insects at Harvard University's Museum of Comparative Zoology. Its wings are in a new active posture that scientists using high-speed photographs of today's dragonflies have determined to be correct for the prehistoric version. "The one thing we don't know for sure, of course, is what the color of the damn beast was," Robinson says. "We've guessed from the behavior of modern dragonflies that it probably had color patterns."

Robinson, who next plans to put a model of the Wright Flyer in the zoo's bird house, attributes his passion for airplanes to growing up surrounded by airfields in England during World War II. His interest in biology was piqued when he began noticing parallels between airplanes and insects.

Does Robinson have any special plans for celebrating the new model's installation? "I'll wear my de Havilland Comet tie for the occasion," he says.

—*David Savold*

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

New Exhibit "Commuting in the Modern Manner": The Grumman "Goose" Amphibian. Includes a recently restored Goose, as well as archival photographs, original timetables, and drawings. Opens November 3 in the Hall of Air Transportation.

New Exhibit "The Aviation Careers of Igor Sikorsky." Includes a VS-300, as well as a variety of models, flight equipment, and photographs. Opens November 16 in the Special Aircraft gallery.

New Exhibit "Too Late for the Past, Too Early for the Future: Drawings and Things by Rowland Emett." Work by the designer of the sets for *Chitty Chitty Bang Bang*, as well as creator of the Museum's "Pussiewillow II." Opens December 14 in the Flight and the Arts gallery.

October 7 Monthly Sky Lecture: "Alaskan Native Skylore." Thomas C. Callen III, NASM. Einstein Planetarium, 9:30 a.m.

October 11 General Electric Aviation Lecture: "The Ultimate High." Chuck Yeager. Langley Theater, 7:30 p.m. Tickets available starting at 5 p.m. at Langley Theater box office.

October 27 Strategic Bombing Film Series: *The Shape of Things to Come* (1936) and *The Possibilities of War in the Air* (1910). Langley Theater, 7:30 p.m.

November 4 Monthly Sky Lecture: To be announced. Einstein Planetarium, 9:30 a.m.

November 16 General Electric Aviation Lecture: "Sikorsky: A Vision of Flight." Ralph Lightfoot. Langley Theater, 7:30 p.m.

November 17 Stategic Bombing Film Series: *Victory Through Air Power* (1944). Langley Theater, 7:30 p.m.

December 2 Monthly Sky Lecture: To be announced. Einstein Planetarium, 9:30 a.m.

December 14 General Electric Aviation Lecture: "Air War in the Falklands." Group Capt. Peter Squire, RAF. Langley Theater, 7:30 p.m.

The Far-Right Stuff

For almost the entire month of April, 1989, Mr. Buckley will host what will surely be, short of flying to the moon, or beyond, the most exhilarating trip of anyone's lifetime. A supersonic record-setting journey, aboard a privately chartered Concorde, to destinations that surpass the mere exotic. We'll be . . . welcomed with the kind of receptions usually reserved for royalty. In some cases entire islands will greet us.

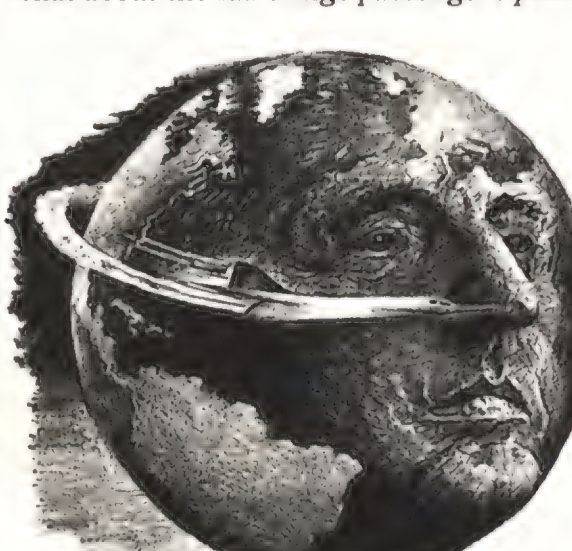
—Lorraine Travel Bureau brochure on a world tour led by William F. Buckley Jr.

Luxury-wise, this was but the tip of the ice sculpture. Many details of what I'll henceforth refer to, for the sake of brevity, as the Blitz Around the World with Bill—BAWB—were not widely reported. Perhaps the tour organizers felt that if word got out about the BAWB's opulence those "entire islands" would show up waving pitchforks and signs reading "Give Us Currency or Kiss Tires Goodbye." But here, at any rate, is a summary of what the passengers enjoyed, for only $39,000 each.

The Mach 2 itinerary, flown almost entirely over water, was: London to New York to Acapulco to Oakland (a less than exotic stop to pick up West Coast boarders) to Honolulu to Papeete, Tahiti, to Christchurch, New Zealand, to Sydney to Perth to Colombo, Sri Lanka, to Mombasa, Kenya, to Cape Town to Monrovia, Liberia, and back to London. But to fully comprehend the treatment BAWBers got we must return to the brochure and luxuriate in its lush prose.

The passengers stayed, of course, only in the finest hotels (Kamuela, Hawaii's Mauna Kea; London's Savoy) and took in the finest sights ("Featherdale Wildlife Park—the best place in the world to hug a koala") and vicariously participated in the shattering of many fine city-to-city speed records—15 all told, with an average speed of 1,074.5 mph. But what really excited my envy glands was all that talk about joyful locals turning out to say "hail" at the tarmac. When I deplane international flights I don't get that. I get earaches, and searched.

Could the BAWB really have been as magnificent as it sounded? Until more tour packagers get in on this business and *Consumer Reports* does an exhaustive evaluation ("Zapp Tours koala-hugging opportunities were merely ADEQUATE; the crowd that greeted us in Bali LACKED FRENZY"), those of you with $43,800 to spend—the price of next spring's tour with Frank Borman—are left in limbo. You know that the BAWB delivered an unscheduled free thrill when the British Airways Concorde lost a six- by five-foot section of its upper rudder over the Tasman Sea, but what about the fun things passengers *paid* for? Would this "investment" have been worth it? To help you decide, I've anticipated some of your questions and searched for answers about the '89 tour.



TIBOR G. TOTH

Who would my fellow fliers have been? Mac Seligman of Creative Resources, the outfit that did Lorraine's marketing research, won't give names, just statistics. Of the 95 passengers, 44 were men and 49 women; ages ranged from "approximately 40" to mid-70s—average age was 63. The best represented states were California, Florida, and "the New York-New Jersey megalopolis." Virtually everybody was "very wealthy" and, owing to the nature of the host, politically conservative. "We consulted an industrial psychologist on this particular project," Seligman recalls. "He said that most people, as they become older and wealthier, tend to become more conservative." In short, they were the same kind of people you'd meet on a Carnival Cruise—only much richer, and more likely to argue with your qualms about visiting South Africa.

What did Bill do? Lorraine's president promised: "Plans call for [Buckley] to change his seating on the plane so that everybody has a chance to have more direct contact with him." Everybody met him, but he didn't exactly serve as a combination Sky Guy, chum, and geopolitical Gray Line host. For one thing, he was busy. He taped several *Firing Lines* and wrote *National Review* columns. For another, I'm told his wife Pat was not a hearty mixer and kept him from partying as much as he might have liked. However, he made up for lack of close contact by lecturing in the hotels and giving a slide show.

Was it worth the price? That's relative, of course. Sheila Cole-Nilva, a journalist on board, feels it was actually a bargain. "It was a dollar a mile, which is what you'll pay on any Concorde flight, with many extras." The overall level of satisfaction, she says, was high, although some passengers kvetched about the luxury accommodations ("It wasn't a big thing—some hotels were just careless about the fact that they were going to have 94 millionaires there") and the inordinate number of barbecues. *But was it worth it?* "Let me put it this way," Cole-Nilva says, "I'm an older lady. I'm not going to get on a spaceship. Traveling at Mach 2 is the next best thing available."

And finally, the one thing we all must know: *Did entire islands really greet them?* Here the BAWB batted .500. In Tahiti they got the standard tourists' hello from native dancers and drummers. But in Christchurch, New Zealand, big things happened. According to Don Pevsner, an attorney and Concorde buff who helped lay out the itinerary, this was the first time a Concorde had landed there. Pevsner claims that 120,000 people "came out to watch us land—that's one out of every six people on the entire South Island of the country."

Impressive. On the other hand, a note to wise consumers: next spring those New Zealanders might be jaded.

—Alex Heard

COURTESY LOUIS R. PURNELL

MARK AVINO/NASM

The Flight of the Bumblebee

A member of the first squadron of black pilots in World War II tells his story.

by Louis R. Purnell

In October 1925 the Army War College prepared a report for the U.S. Army chief of staff. Titled "The Use of Negro Manpower in War," it concluded that blacks were fair laborers but inferior technicians and fighters. It also stated that the cranial cavity of the Negro was much smaller than the white's and that the Negro's brain weighed 35 ounces, versus 45 ounces for the white's. Other studies concluded that blacks lacked patriotism, were difficult to discipline, told lies, and ran off in times of danger.

It was upon this basis that the faculty and students of the Army War College and, in later years, officials at the Pentagon decided that no blacks should ever become pilots in the Army Air Corps.

That always reminds me of an old theory that holds that because of its wingspan-to-weight ratio, the bumblebee shouldn't be able to fly. But the bee, unaware of this, flies anyhow. The same was true of us.

During World War II, I was a member of the 99th Fighter Squadron—the first squadron of black pilots. In the struggle for racial equality during the war, we did as much as—if not more than—any other group I've ever known. We fought two wars: one with the enemy and the other back home in the U.S.A.—Hitler and Jim Crow. Progress was difficult in both cases, but our victories were sweet.

For black aviators like Lou Purnell, the right to fly was a greater prize than the air medals they later won.

I had wanted to fly since I was a child. My chief inspiration was a six-foot-two, 200-pound native of Trinidad who branded himself "the Black Eagle of Harlem." Hubert Fauntleroy Julian was an elegant rogue with a haughty air. He impressed thousands with his black derby, monocle, wing collar, Prince Albert cutaway coat, striped trousers, and spats. As a six- or seven-year-old, I had no idea that Julian would go on to achieve all kinds of notoriety as the clown prince of black aviation.

One Sunday this dashing figure came to our church in Wilmington, Delaware, to deliver a speech about aviation and collect funds toward the purchase of an airplane for a solo nonstop flight from New York City to Rome, Italy. After a plate was passed for Julian, he invited us to an airshow to watch him make a parachute jump. He was to play a saxophone while descending.

At the airfield, a chauffeured La Salle convertible passed before the grandstand carrying Julian dressed in a flying suit. The car veered off and disappeared over a hill at the far end of the field. A few minutes later an airplane took off. At high altitude a tiny figure jumped out, the chute opened, and the jumper landed—no saxophone in sight. As the rest of the crowd turned its attention to airplane displays in the hangar, I happened to catch a glimpse of a truck rolling up behind the building with a billowing parachute in the back. I ran up,

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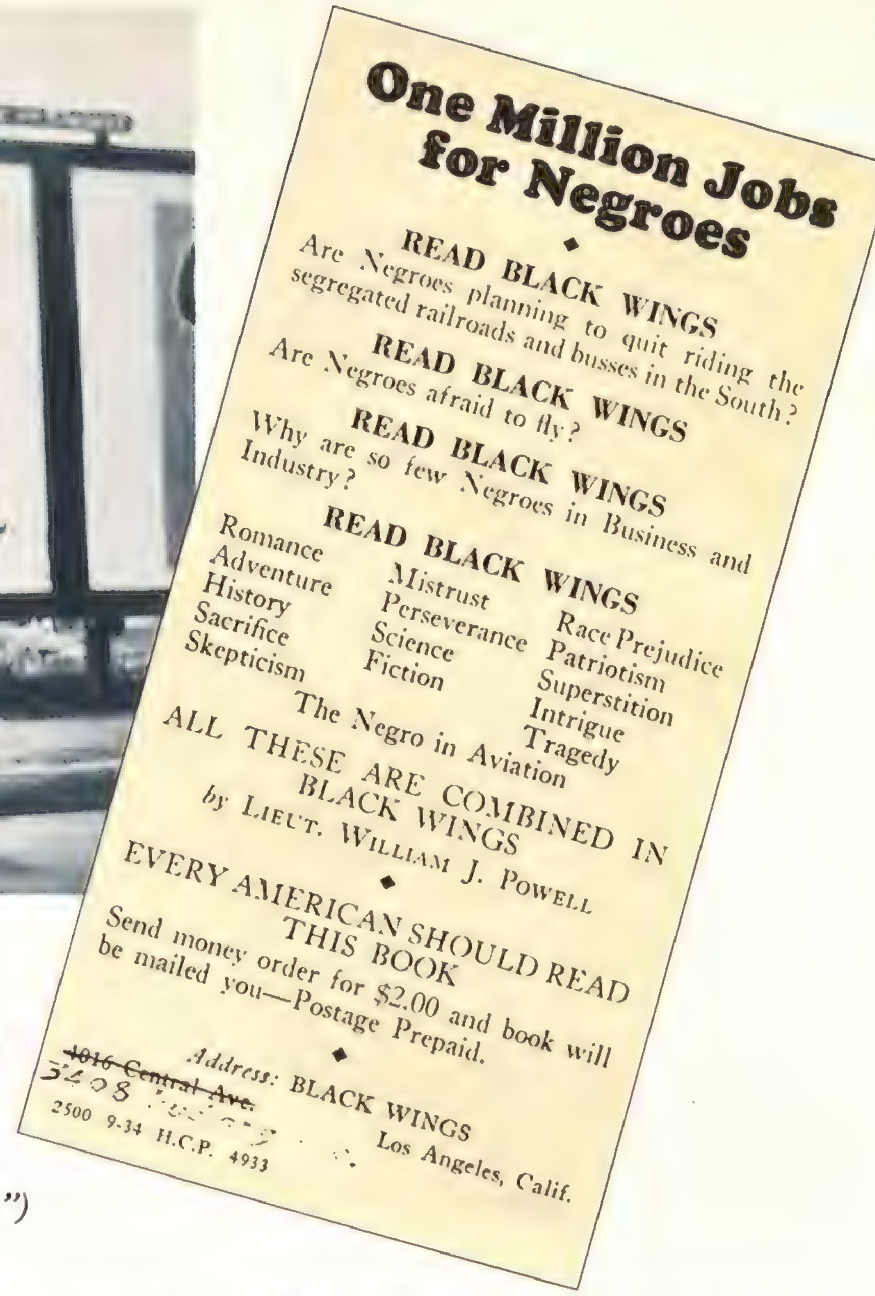


Flamboyant or scholarly, early efforts to promote black aviation did little to sway the general public. (Despite Hubert Julian's renown, the billboard identifies him as "Rupert.")

eager to get a close look at the star of the show, only to discover that the jumper in the truck was not Julian. Somewhere a quick switch had been made. A few minutes later Julian reappeared in the La Salle, an open parachute trailing behind him, to soak up the accolades of the small crowd.

Julian's shenanigans were numerous. There was at least one parachute jump he actually did make: over New York City without a license. He landed on the skylight of a police station. At various times Julian posed as a government advisor, fundraiser, barnstormer, bodyguard, lobbyist, stunt pilot, rum runner, foreign correspondent, air marshal, lecturer, mediator, mercenary, arms dealer, movie producer, inventor, double agent, and diplomat.

In retrospect, I reluctantly admit I was one of the thousands he had duped. Nonetheless, as a black pilot, he was an inspiring role model for a black child. I was determined to fly.

It was becoming obvious as I grew older, however, that my race would be a major obstacle. It was my father who told me: "In order to appear equal, you've got to be twice as good." It shouldn't be that way, but unfortunately, I've found this to be true.

During the autumn of 1939, when I was a student at Lincoln University in Chester County, Pennsylvania, the Civilian Pilot Training Program established flight schools at several colleges and universities throughout the country. Six Lincoln students signed up immediately, and all six of us earned our wings. In the summer of 1941, I headed for the Tuskegee Institute in Alabama, where a Civilian Pilot Training Program offered advanced training to those who had successfully completed the primary course. I finished the course in September, but my color prevented me from going any further: blacks were not accepted as aviation cadets.

By the time I reached this obstacle, I was feeling desperate. But I wasn't the only one. In January 1941, Yancey Williams, a student at Howard University in Washington, D.C., appealed to the NAACP to file suit against the Air Corps to admit him to one of its training centers. In May, unaware of Yancey's legal action, I also asked the NAACP for help. But before Yancey's suit came to trial, the Corps relented under mounting social pressure and began accepting black pilots for training.

Two weeks after the attack on Pearl Harbor, I left Lincoln University. I underwent my physical examination and in January reported to Tuskegee Army Air Field as an aviation cadet.

The washout rate there was exceptionally high compared with the per-

The skilled leadership of Benjamin O. Davis Jr. helped turn the tide of prejudice against black aviators.

centage of failures at Maxwell Field in Montgomery, where white pilots were trained. It appeared to us at Tuskegee that those in power were trying to limit the number of black graduates. Still, those of us who managed to graduate against the odds had the feeling that we had what it took.

The first full-fledged Army Air Corps pilots to graduate from Tuskegee did so on March 7, 1942. There were five—one officer and four cadets. The officer, Benjamin O. Davis Jr., was a West Point graduate who had ranked 35th of 276 in his class. I earned my wings a few months later and joined 26 other pilots to form the 99th Fighter Squadron under Davis' command.

We were undoubtedly the most highly trained squadron in the U.S.: the Air Corps brass couldn't decide what to do with us so we flew and flew for nearly a whole year simply to maintain our proficiency. It looked as though the black squadron was in danger of becoming a white elephant, so reluctant was the brass to send us into battle.

Finally, on April 15, 1943, we left for North Africa, and by June we had settled down to the business of war and begun flying missions in our P-40s. Although we were resented by some of the white fliers, we found that a strong feeling of camaraderie usually prevailed among fighter pilots regardless of their race. I learned that the day I experienced my first close call.

The squadron was returning from a dogfight near the Italian island of Pantelleria, and we were still out over the Mediterranean when my engine began to act up and stream black smoke. Aware that a smoking engine could attract attention, low on fuel, and anxious to reach land, the squadron made a decision. It poured on the coal and left me dangling. The minutes that followed were some of the longest of my life.

I saw four planes in the distance approaching from my left. I flicked the gun switch to "on," although the odds were against me, and prepared to go down fighting. I was one happy soul when I recognized that the four planes were not Hitler's boys but from the white squadron based near us. They stayed with me until I was over land.

On July 2, a group of Luftwaffe fighters came up to attack the bombers we were escorting. Our squadron broke formation and counter-attacked. A few minutes later Lieutenant Charles B. Hall of Brazil, Indiana, shot down a Focke-Wulf 190, becoming the first black Air Corps pilot to down an enemy aircraft.

That afternoon we celebrated, and "C.B." was awarded the closely guarded squadron prize, which had been held in a safe since May for just this occasion. Eyes and mouths watered as C.B. took the chilled bottle of Coca-Cola and guzzled it down to the last drop.

Since the taking of the island of Pantelleria, which was the first battle in history in which air power alone completely destroyed all enemy resistance, the 99th had been taking on an increasing role of ground attack: dive-bombing and strafing. Although we thought of it as dirty work, we had become dive-bombing experts, and I considered dive-bombing and strafing my specialties.

July 14 found the 99th well established at Biscari airfield, which had just been captured by the ground forces. We continued to attack enemy strongholds and patrol the area, as well as perform armed reconnaissance. Yet we were criticized by high Air Corps officials for not scoring more aerial victories. They began to question our courage. We wondered how we were supposed to win aerial battles when we had been ordered to perform ground attack.

Our job was to work on the infantry front lines. As the bomb line moved north, so did we. By the time we moved to Cefalù in northern Sicily, I had completed my tour of duty—50 missions.

I left Palermo, Sicily, on a B-24 bomber. On the way back to the States I struck up an acquaintance with a white

COURTESY LOUIS R. PURNELL

Tuskegee cadets gather at a formal assembly. The first graduating class is seated in the front row.

NASM

fighter pilot from Lumberton, North Carolina, who had also completed his tour of duty. At each stop on the trip, he and I would head out to see what the nearest town had to offer in the way of entertainment. He had a good sense of humor, and we got along well.

We finally landed at Eglin Field, Florida, in a drenching rain at about 10 p.m. We jumped down from the airplane and I was about to offer my hand in congratulations when he turned away from me. I was hurt, but not terribly surprised, I suppose; considering that I was black, he was white and from the South, and we were back home, I accepted his behavior as normal.

A steady stream of staff cars began approaching, taking two or three men each off in the direction of the barracks or BOQs—Bachelor Officers Quarters. I saw my friend pause before entering the car waiting for him and turn to look in my direction. The headlights illuminated his face and his eyes looked wet. His face bore an expression I didn't quite know how to interpret.

When a Jeep pulled up for me, I loaded it with my duffel bags and jumped in. But the driver did not follow the cars toward the buildings; he headed toward the gate, off the field, and into Tallahassee, where he stopped in front of a boarding house. My long-held hopes for a hot shower, a good dinner, and a visit to the officers' club were shattered to bits. A hell of a reception for one who had just returned from fighting for his country!

The next morning the driver picked me up and took me back to the dispersal point on the field for the flight to Fort Dix. In the crowd I spotted my Lumberton friend. He said he could have told me what was about to happen the previous night but got so choked up he couldn't get it out. He said he didn't understand why I couldn't stay on the base last night and reasoned that since both of us had risked our lives defending our country, the least the authorities could do was let me stay in the BOQ. After what I'd assumed about him, his explanation surprised me and made me vow not to prejudge.

From Fort Dix I went on to New York City, where I made a beeline for the Theresa—the best, the most widely known, and, to my knowledge, the only decent hotel where blacks were allowed to register during those times. The next morning I received a call from the front desk informing me that I had a visitor. In the elevator, I tried to guess who it might be. I never could have succeeded.

The elevator doors opened and there stood Hubert Fauntleroy Julian, looking much as he had when I was an impressionable seven-year-old. He went into his act immediately. Strolling up and down the lobby with one eye on a small audience, he said in a loud voice, "Is this any way to treat a returning hero? He should be out on the town. Give him the keys to the city." He rummaged through his pockets. "Here—here are the keys to my car. Return the car whenever you wish, tomorrow or whenever you're finished. It's right outside, around the corner."

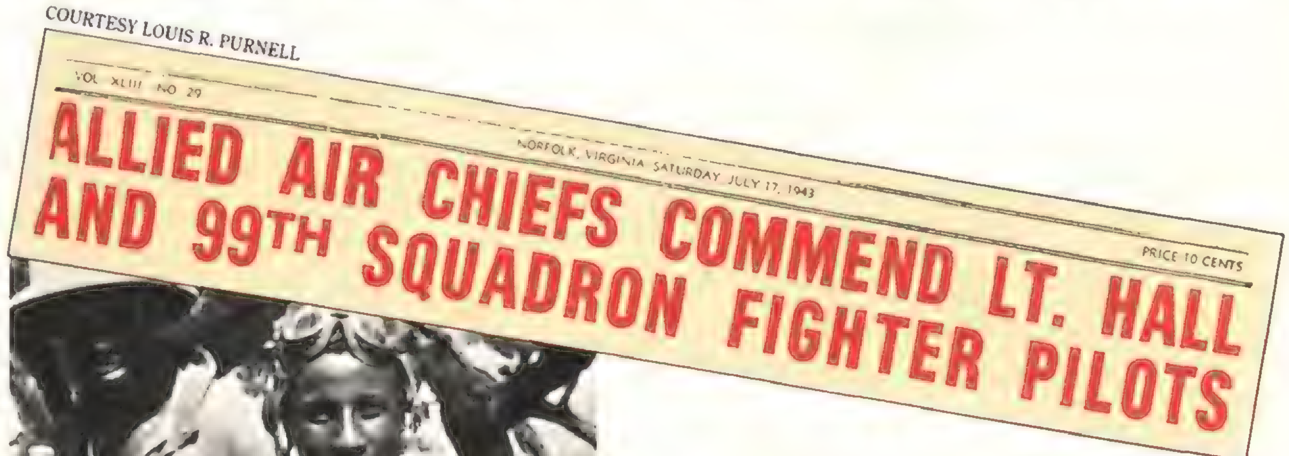
I felt like two cents, being put on display like this, and could have hidden in the pile of the carpet. But I thanked him and set out to identify the car. I found it quickly enough: a big black Cadillac with a ticket on the windshield parked beside a fire hydrant. I removed the parking ticket, got in, turned the ignition—and saw that the gas gauge registered empty. The old fox's plot included me, my gasoline ration card—which he didn't know I lacked—and a full tank. I drove the car around the block, parked it in the space where I had found it, replaced the ticket, and returned to the hotel to give Julian the keys. He was still holding forth in the lobby, and he berated me in the presence of the people there, telling me that I didn't know how to accept things graciously. Then, after he lost his audience, he invited me to come to his house for breakfast the next morning.

The Black Eagle appeared at his door dressed in a satin smoking jacket and wearing the ever-present monocle. But I could have cried when I entered his home. There was no furniture in the living room, and nothing but a big round oak table in the dining room. The kitchen held only a table and chair.

I couldn't smell any food cooking. (Had he expected me to bring it?) I backed out of the invitation politely, explaining that I had other appointments. I really pitied Julian. He was living in another world, still playing the part of a king in a cold, empty house.

That was the last time I saw Julian in

COURTESY LOUIS R. PURNELL



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A triumphant Charles Hall received a much appreciated prize after scoring the 99th's first victory.

A member of the 332nd (third from top) flies in formation with members of three white squadrons.

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The Tuskegee Experience

Few people know that a black American, Eugene Jacques Bullard, flew with the French during World War I. Nor do many Americans know that Bessie Coleman, a black woman forced to go to France to learn to fly, gave aerobatic exhibitions across the United States during the early 1920s. Such early demonstrations of the competence of black aviators did little to dissuade white America from denying blacks access to government and most non-government aviation programs.

Anti-black sentiment proliferated in the United States during the final years of the 19th century and the beginning of the 20th. The military followed the rest of the country down the racist path despite the fact that blacks had fought in all of the nation's wars except the Mexican war; near the end of the Civil War, blacks made up about 10 percent of the Union Army.

When it became clear that the United States would enter World War I, throngs of blacks volunteered for service—and were turned away. It was not until the passage of the Selective Service Act in May 1918, which called for the enlistment of all able-bodied Americans 21 to 31 years of age, that blacks were accepted in significant numbers. However, blacks were specifically barred from serving as pilots with the Army Air Service.

The admission of blacks to government-sponsored flight training did not occur until 1939, after Congress passed two bills with specific provisions for the training of blacks. Public Law 18, passed in April, authorized the expansion of the Army Air Corps and required that one of the civilian schools contracted to conduct primary flight training had to be designated for the training of blacks. The Army Air Corps completely disregarded this order. The Civilian Pilot Training Act, passed in June, created the Civilian Pilot Training Program, a program intended to provide a pool of civilian fliers that could be enlisted in the military in the event the United States was drawn into a world war. The act which contained an amendment prohibiting discrimination, provided for the training of blacks at six black colleges and two privately owned facilities, both in the Chicago area.

In January 1941, after several months of planning how to—and how not to—implement the training of blacks and a day following the filing of a suit against the Department of War by Howard University student Yancey Williams, the Army Air Corps announced that it was creating the 99th Pursuit (later Fighter) Squadron to accommodate the training of blacks.

Several factors were responsible. The black press applied continuing pressure, as did active lobbying by the NAACP and the Urban League. In 1939 the National Airmen's Association, an organization of black pilots, mechanics, and supporters, sponsored a demonstration flight from Chicago to Washington, D.C.; the successes of black pilots in the Civilian Pilot Training Program also went a long way in advancing the cause. And finally, there was the Selective Service Act of 1940, which declared there would be no discrimination in military service on account of race.

Lou Purnell and others lucky enough to be selected as pilots in the Army Air Corps' new training programs were assigned to the just-constructed Tuskegee Army Air Field near Tuskegee, Alabama. Mechanics were trained at Chanute Army Air Field near Rantoule, Illinois, as were non-flying officer candidates in the technical specialties of armament, aircraft maintenance, and communications. Throughout the war, Tuskegee was the only place where blacks were trained to fly combat aircraft.

Following the formation of the 99th, the Air Corps authorized the establishment of three more fighter squadrons—the 100th, the 300th, and the 301st—which were organized into the 332nd Fighter Group. In late 1943, military officials decided to train blacks to fly twin-engine airplanes and form a bombardment group. At the same time, they also decided to train navigators, bombardiers, radio operators, and gunners. The 477th Medium Bombardment Group consisted of four squadrons—the 616th, 617th, 618th, and 619th. The 477th became combat-ready but was never sent overseas.

The program at Tuskegee produced approximately 992 black combat pilots, 450 of which served first in North Africa in the 99th Fighter Squadron as part of the 12th Air Force and later in Southern Italy in the 332nd Fighter Group as part of the 15th Air Force.

In the course of 1,578 missions, the Tuskegee airmen shot down 111 airborne craft, destroyed 150 on the ground, and damaged 25 airborne and 123 ground-bound craft. They are the only group that never lost any bombers to enemy fighters while flying as escorts.

In his recently published book *Those Who Fall,* B-17 pilot John Muirhead writes with admiration of the 332nd. It was sheer bravery, Muirhead felt, that accounted for their unique method of bomber escort: the 332nd pilots stayed with the bombers throughout the bomb run, instead of waiting for them to come out of it. Their "insouciance was too brazen," Muirhead wrote, "their contempt for any part of the sky, except the corridor directly over our bomb run, was too brave a choice for me to remember them in any way but as the best of shepherds."

—Theodore W. Robinson

person. However, he continued to make himself conspicuous. Years later he appeared on the Dave Garroway and David Frost TV shows. In 1977 the *Washington Post* published an article listing the names of several distinguished foreigners—including one U.S. citizen—caught shoplifting in London's major department stores. "Last summer's bag included the famous 'Col.' Herbert [*sic*] Fauntleroy Julian," the article read. "The Black Eagle, as he was known for his alleged flying exploits half a century ago, tried to soar out of Selfridge's with [£1,500] worth of electronics under his arm. Since the 'colonel' admits to being 78, his exploit drew reluctant admiration even from [the] security chief . . . ."

What was that I'd said about a role model? Well, we all make mistakes.

Following my leave—and happy to leave some parts of it behind me—I reported back to Tuskegee Army Air Field in October 1943, where my new assignment was to instruct a group of five aviation cadets. On his last dual instruction, one cadet froze at the controls while I was teaching him to recover from spins in an AT-6. Deciding that combat might be a little safer, I requested permission to join the 332nd Fighter Group. Formed of four black squadrons, including the original 99th, the 332nd was headed for combat under Colonel Davis' leadership.

After a month of sailing aboard a Liberty Ship in early 1944 we arrived at Taranto, Italy. We occupied bases at Salerno and Naples and eventually set up a base in Ramitelli, on the east coast. The airplanes we flew—P-40s, P-39s, and P-47s—were hand-me-downs, but our linemen did an excellent job of keeping them airworthy. The best planes were yet to come.

I can't find enough adjectives to describe my feelings about the P-51. Good response to controls, stable, smooth, powerful, quiet engine, good cockpit visibility, speed, rate of climb, reliability—it was the best fighter aircraft ever built by the United States. The Mustang was a real sweetheart. Had it been a woman, I would not have hesitated to marry it after the first time I flew it.

The 332nd was making progress; our victories were on the rise. By the winter of 1944 we were escorting B-24s and B-17s as they bombed oil refineries, marshaling yards, and munitions factories in Germany, Austria, and Czechoslovakia. Our highest score for one day was 13 victories. At last we were changing public opinion about our abilities as fighter pilots. Our group never lost a bomber to enemy fighters.

One day around Christmas of 1944, weather forced the bombers we were escorting to land at our base. During the two days the bomber crews stayed with us, one of the "duties as assigned" I was performing was censoring the enlisted men's mail. I came across one letter I must have read 50 times. It read in part, "Dearest, . . . The most sentimental time of the year is approaching. It makes my heart bleed to know that I'll not be with you at Christmas. May God speed the end of this war . . . . [I]t's bad enough I'm not on my own base. I'm stranded at a nigger base, eating nigger food and sleeping in a nigger bed." The return address indicated the letter was

Pre-mission activities: a 99th pilot studies a map and an armament technician loads ammunition. By the time the 99th joined the 332nd in 1944, the group was attacking enemy installations and engaging in air combat.

CAROLINE SHEEN

Forty-six years after reporting to Tuskegee as a cadet, the author poses at home with his wife JoAnn.

from a Sergeant Schwartz.

The next day, as the crews began to assemble for takeoff, I located Schwartz when he was away from the rest of his crew. "Sergeant Schwartz," I said, "after all, it wasn't so bad sleeping in nigger beds and eating nigger food, especially when we protect you in flight. I'll see you up there." I turned and walked away without bothering to see the expression on his face.

Despite such episodes I still considered myself lucky: after flying dozens of missions, I remained physically unscathed. My most serious injury, in fact, was a rather inglorious one: I was hit by a Jeep while sleeping in my tent—the result of the squadron cook's attempt to teach himself to drive.

There were close calls, though. One occurred while I was escorting bombers on a secret mission. I was at 18,000 feet when a feeling came over me. This was the best day of my life. Everything was beautiful. I could hear music coming from nowhere. I had an urge to roll back the canopy, climb out on the cowling, and direct all 63 airplanes as though they were an orchestra.

Then, about five minutes later, it seemed as though someone had lowered a gray mosquito net over my eyes. I felt that I was going to be sick; I grew careless and didn't give a damn about maintaining my position in the formation. I desperately wanted to sleep. The plane veered off in a descending right turn. My vision began clearing as I approached lower altitude, but the sick feeling remained.

I learned later that I was suffering from hypoxia, or insufficient oxygen. Either my oxygen supply had sprung a leak or the regulator had malfunctioned. At the moment, though, my only thought was to try to land safely.

The nearest landmark was the island of Vis, off the coast of Yugoslavia, which was known to have been occupied at one time by the Germans. After I landed, Yugoslavian soldiers from the anti-communist Chetnik faction found me and took me to a shepherds' hut. Although I had been told that American pilots would be safe on Vis, I had my doubts.

The next morning a crowd of about 50 old men, women, and children had gathered around the hut. Word had traveled fast. I spotted a woman in the crowd holding a baby, and when I reached toward it the baby took hold of one of my fingers. The woman offered me her child as though she were handing it to some strange creature. I held the baby for a few seconds, then gave it back to the woman. As a soft murmur spread through the crowd, I knew I was safe.

One other episode is still particularly vivid to me. We were on a strafing mission over Yugoslavia when we spotted a long convoy of German trucks. Swooping down to treetop level and below, we blasted them right and left. Some returned fire with their machine guns.

After returning to the base, I checked the aircraft—a brand new P-51 on its maiden combat mission—for bullet holes. Hanging over the edge of the airscoop beneath the plane was a strange object—a black-brownish glob, wet in some spots. I poked at it with a stick and it fell to the ground. A fleshy glob. Then it dawned on me: this was part of a man.

My first thought was *Better he than I.* And then I began to think seriously about what had happened. At their point of convergence, bullets from a P-51's six 50-caliber guns have a disintegrating rather than penetrating effect. Debris flies in all directions. Eighty minutes ago that man was alive, healthy, and whole. His parents had raised him just as mine had raised me. He had nothing against me personally, and I had nothing against him, but since our countries were at war, killing was legal. When called to arms, one must defend his country.

But it all seemed so futile: nations trying to force their forms of government and ways of living on other nations, all the while knowing that wars never really settle anything. The result is men without fathers and fathers without sons.

I was also well aware that had it not been for the war, I would never have been able to fly. The war dramatically improved the situation for black aviators. Afterwards, blacks became commercial pilots. In Korea and Vietnam the Air Force was integrated. Benjamin Davis and other blacks became generals. Today we have black astronauts.

I think they were all accepted a little more readily because of what the pilots of the 99th squadron had gone through. It was just another rung on the ladder we were trying to climb to disprove that old theory of black inferiority. *Per aspera ad astra,* as the saying goes—to the stars through difficulties.

How can you make your money go farther when you travel?

- ○ *Stow away.*
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To Mars and Beyond

When people travel to other planets, what will they have under the hood?

by Ben Bova

Illustrations by Paul DiMare

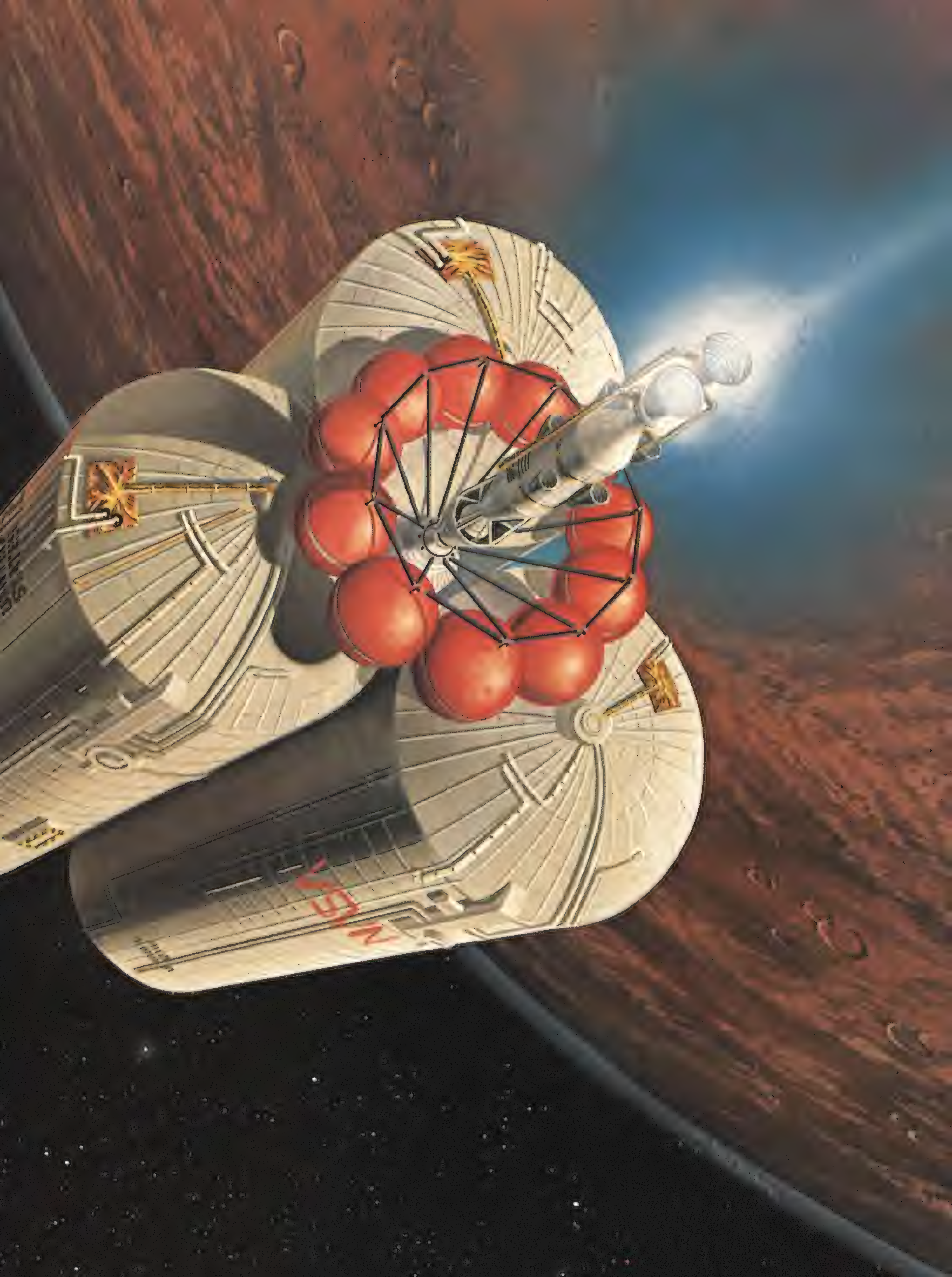
Last summer President Bush chose the 20th anniversary of the moon landing to outline his objectives for space. Surrounded by the Apollo 11 astronauts and models of the Saturn V and the *Eagle* at the National Air and Space Museum, he called for a renewed commitment to the space station, a permanent moon base, and "a journey into tomorrow, a journey to another planet, a manned mission to Mars."

Human exploration of the solar system, particularly of the moon and Mars, is already under study by NASA, which has developed four case studies. According to one scenario, the first human voyage to Phobos (the larger moon of Mars) could take place as early as 2003.

It would be a long trip. Mars at its closest is 35 million miles from Earth—over 100 times the distance to the moon, which took three days for the Apollo astronauts to reach. What kind of spacecraft could get us to Mars?

The rockets that we have been using to boost spacecraft into orbit and be-

Riding a nuke to Mars: thrust is provided by a reactor that heats hydrogen from large tanks.



yond have all been chemical rockets. They get their energy by burning a fuel and oxidizer and firing the resulting hot gases out of the rocket's nozzle. The hotter the gas, the faster it flows through the nozzle. The faster it flows, the more forward thrust it provides.

All other internal combustion engines "breathe" air and require the oxygen in our atmosphere to burn their fuel. However, rockets carry oxygen or other chemicals that burn the fuel, allowing them to operate in space far beyond the limits of Earth's atmosphere.

Rocket engines can be rated in two ways, like automobile engines. An auto engine can be rated by its horsepower or its fuel efficiency (miles per gallon). A rocket engine can be rated either by its thrust or by its efficiency, which is given as "specific impulse."

Thrust is easy to visualize. It is raw power, the pushing force that moves the booster or spacecraft. It is usually measured in pounds. A pound of thrust will lift a pound of spaceship.

Specific impulse is the measure of how long a pound of propellants will yield a pound of thrust; it is rated in seconds. Different propellant mixtures give different specific impulses. Specific impulse is also dependent on the gas pressure inside the rocket chamber.

The space shuttle orbiter's main engines are the most efficient chemical rockets yet developed. Burning liquid hydrogen and liquid oxygen, they are rated at a sea-level specific impulse of 375 seconds and a vacuum specific impulse of 455 seconds. (Vacuum specific impulse is always better because in a vacuum there is no air to hinder the expansion of the rocket exhaust gases.) This is considerably better than most rocket engineers dared dream of as recently as the 1960s.

But even the most advanced chemical rockets will not be able to deliver specific impulses above 500 seconds, so we must look beyond chemical rockets for efficient interplanetary propulsion. "Chemical fuels have gone to the limit and are barely able to get us off the ground, much less get us around the solar system," says Robert Forward, who has been working with the Air Force's rocket propulsion laboratory since recently retiring as a senior scientist at Hughes Research Laboratories in Malibu, California (see "Forward Motion," June/July 1987). However, there are a number of alternatives, each with its own obstacles, or "tall poles" in the parlance of the industry.

Even before Wernher von Braun developed the chemical rockets that took us to the moon, nuclear energy was considered for space expeditions. Before the 1962 nuclear test ban treaty brought its development to a halt, physicists Freeman Dyson and Theodore Taylor were designing an interplanetary starship known as Project Orion (see "A Spaceship Named Orion," October/November 1988). An Orion spacecraft would have been propelled by detonating nuclear bombs behind the vehicle.

One alternative, a non-explosive nuclear rocket, could "burn" fuel in a reactor, which provides an excellent source of heat. Every day here on Earth, power plant reactors create heat from nuclear fission, the splitting of massive atomic nuclei such as those of uranium and plutonium. The heat produces the steam that drives a power plant's turbines.

Chemical fuels are barely able to get us off the ground, much less around the solar system.

Smaller and more efficient nuclear reactors could be used in space to heat a propellant and provide thrust. It is not necessary for the propellant to supply the system's energy, as in a chemical rocket. The nuclear reactor provides the energy; the propellant merely carries it out through the nozzle. Thus the propellant is often called the working fluid in non-chemical rockets. ("Fluid" describes either a liquid or a gas.)

A compact nuclear reactor in space could provide nearly twice the specific impulse of the most efficient chemical rockets by heating a propellant—liquid hydrogen would be the best—and releasing it out of the rocket's nozzle to create thrust. Since the exhaust gases would be radioactive, nuclear rockets could not be used as boosters to lift spacecraft from the ground. They are envisioned as propulsion systems for spacecraft already launched by chemical propulsion.

Even after Project Orion's demise, the United States continued to pursue development of nuclear rockets. In a program called NERVA (Nuclear Engine for Rocket Vehicle Application), some 20 tests were run on a solid-core nuclear thermal rocket in Jackass Flats, Nevada. But in the late 1960s the NERVA program was scrapped. With Vietnam diverting Washington's attention and the space program at an ebb, NASA couldn't justify future missions requiring the complexity, cost, and technical risks of nuclear propulsion.

"Nuclear propulsion could be made to happen sometime in the first decade of the next century with enough of a technology push," according to Ivan Bekey of NASA's Office of Exploration. Last winter at the Sixth Nuclear Space Symposium in Albuquerque, New Mexico, Soviet engineers discussed their plans for nuclear propulsion.

In addition to nukes that use solid material such as uranium or plutonium, a gas-core nuclear rocket is also under study. Gas-core reactors using gaseous uranium hexaflouride as fuel would enable higher temperatures to be reached than those achieved by solid-core reactors. Considerably more efficient and capable of high thrust, a propulsion system based on a gas-core nuclear reactor could provide a round trip to Mars in less than 100 days—but a gas-core nuclear rocket system would take much longer to develop than other, better understood propulsion systems.

Nuclear power can be used in another way: to provide the energy input for electrical rockets. Electrical energy can heat a propellant, or it can directly accelerate a conductive working fluid to very high velocity. This can produce a rocket system that is extremely efficient, with specific impulses in the range of 1,000 to 10,000 seconds or even better. Unfortunately, most (but not all) electrical rocket systems produce very low thrusts.

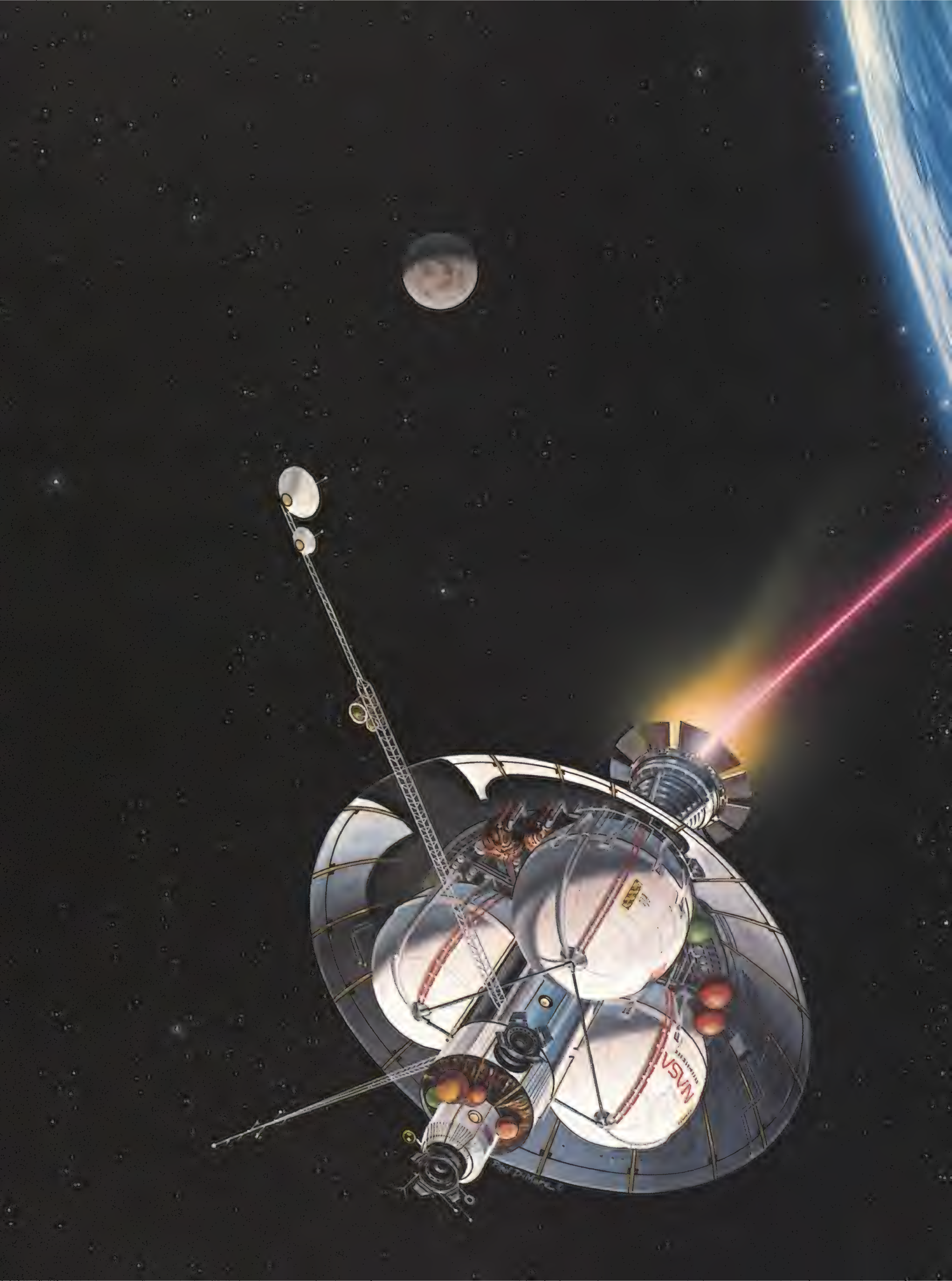
To date, several types of electrical rockets have been tested. The resistojet heats its working fluid—usually hydrogen—by electrical resistance, much as an electric stove generates heat. Spe-

The Nuclear Thermal Rocket

"What we are attempting to make is a flyable compact reactor, not much bigger than an office desk, that will produce the power of Hoover Dam from a cold start in a matter of minutes." That's how Glenn T. Seaborg, then chairman of the Atomic Energy Commission, described the Nuclear Engine for Rocket Vehicle Application project of the 1960s.

A rocket based on NERVA technology currently offers the best prospects for a manned mission to Mars. It would be able to carry out a round-trip Mars mission in about a year. A nuclear-powered engine—the most thoroughly tested of the advanced propulsion options—could be ready within the next two decades.

Heat from a fission reactor would be used to raise the temperature of the propellant, which would then be expanded through a nozzle to provide thrust. But because its exhaust gases would be radioactive, the rocket would have to be assembled in space, and the reactor could not start until the spacecraft reached its assembly orbit. To protect the crew from radiation, hydrogen storage tanks would shield the crew module and payload, which would be located as far as practical from the reactor.



cific impulse is limited to about 1,000 seconds, largely because it is difficult to produce higher temperatures without damaging the heating elements. Small resistojets have been used as attitude-control thrusters on satellites.

The ion thruster has been flown in NASA's Space Electric Rocket Test program. A working fluid that conducts electricity, such as mercury or ionized argon gas, is accelerated by electrical energy rather than heat. Specific impulses of 10,000 seconds or more are possible, depending on the amount of electrical power put into the fluid. Ion thrusters can also be powered by solar-voltaic cells, which convert sunlight directly into electricity.

The third type of electrical rocket is the plasma thruster, in which electromagnetic fields accelerate an electrically conducting working fluid, such as argon mixed with a slight amount of cesium "seed." (A gas that has been ionized to the point where it easily conducts electricity is called a plasma.) Plasma thrusters produce more thrust per weight than ion thrusters and are capable of specific impulses of 10,000 seconds or more.

But the real handicap to electrical rockets is that they are limited by the weight (or, in space, the mass) of their electrical power systems. The more electrical power needed, the more massive the power generator must be, and for most electric power systems the mass of the generator tends to increase at a rate that outpaces the increase of its power output. Ultimately, the low levels of thrust available through electric propulsion restrict its use to unmanned cargo missions to Mars.

The line between science and science fiction starts to blur with the advanced propulsion concepts designed to get around the problem of the large masses required by electrical and chemical rockets. Here, researchers freely admit that the physics involved are not always understood.

The solar sail, first proposed by Soviet spaceflight pioneer Konstantin Tsiolkovsky in the 1920s, would not use rockets at all. It would be propelled by the pressure of the light from the sun. (Light exerts pressure, although the amount is so small that delicate laboratory apparatus is needed to measure it.)

Since no propellant is used, the solar sail's specific impulse is infinite. But to get any reasonable amount of acceleration from such a minuscule push, a sail would have to be enormous—a huge galactic butterfly more than a quarter-mile across. Constructed of a plastic such as Kapton and coated with aluminum to reflect sunlight, a sail could be as thin as 4/100,000 of an inch—about half as thick as magnetic tape. The bigger the sail, though, the heavier it becomes and the more difficult to accelerate.

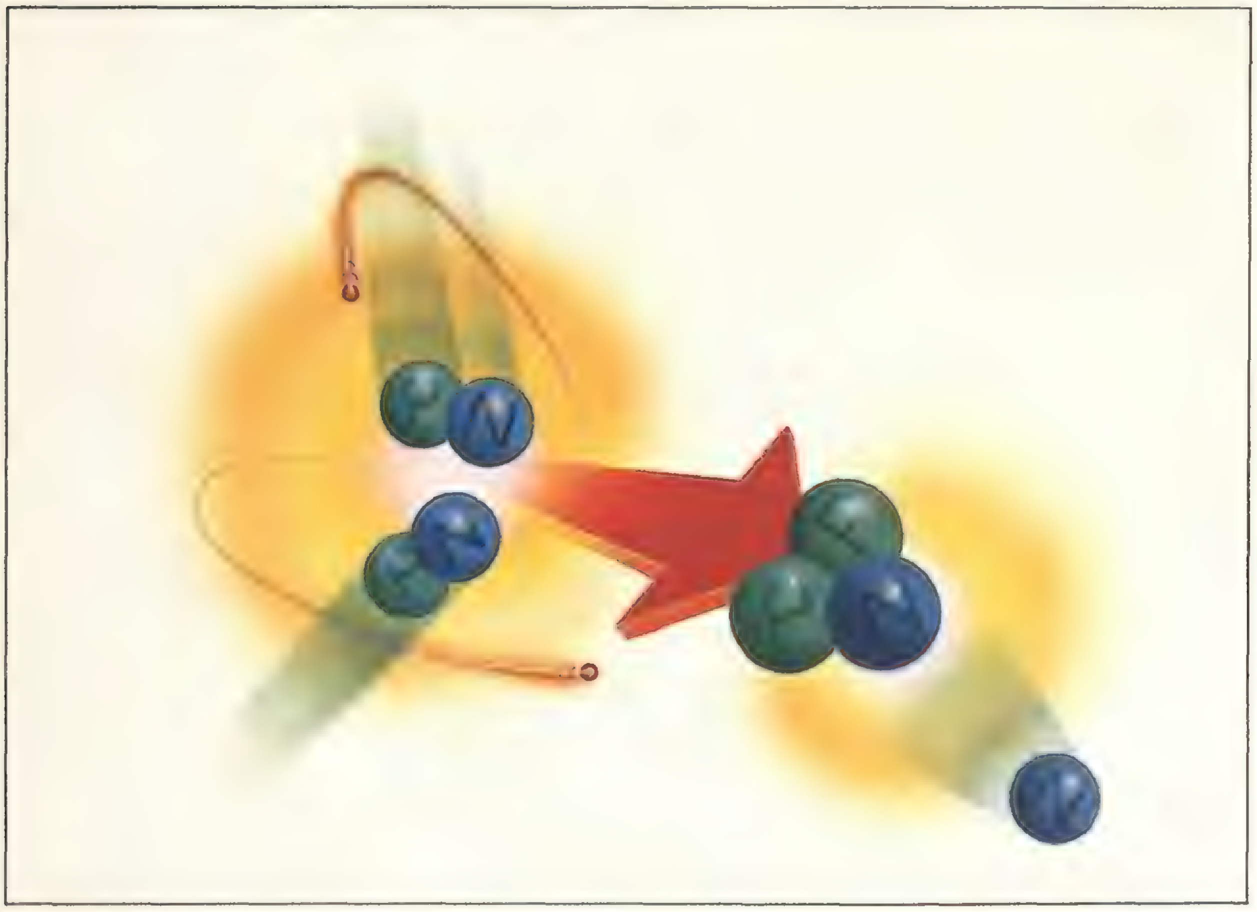
Unless a crew is willing to spend several years before the mast, solar sails are not for manned spaceflight. However, one variation of solar sailing would use powerful lasers, not sunlight. Instead of carrying its heavy propulsion system with it, a laser-propelled craft would have a main energy source at a remote site that transfers energy to the moving vehicle, the way a remote generating station powers an electric trolley car.

Arthur Kantrowitz, now at Dartmouth University, is the father of another concept of laser propulsion. In Kantrowitz's system a rocket would use energy beamed from a remote laser to heat its propellant. He believes that laser propulsion could be operational in the 1990s. Laser-propelled spacecraft could carry payloads that are 50 percent of their total liftoff weight, rather than the one percent of today's space shuttle.

Lasers of unprecedented power (10 megawatts or more) and pointing systems of astronomical precision would have to be developed for laser propulsion. The Strategic Defense Initiative program is currently attempting to develop lasers powerful and accurate enough to destroy ballistic missiles. Satellites already lifted to low orbit by the space shuttle or an expendable booster could be raised to higher orbits by the same lasers.

Robert Forward envisions an interstellar sail concept called Starwisp. A variant of the laser-pushed sail, it would be propelled through the far reaches of

Not unlike a trolley car, laser-propelled rockets would receive energy from a remote source, freeing a spacecraft from the burden of carrying a propulsion system.



Fusing nuclei of deuterium ("heavy hydrogen") creates helium and millions of electron volts of energy—enough to take us to Mars in a weekend.

the solar system and even out toward other stars by microwaves from a solar power satellite in orbit near Earth. Forward believes that Starwisp could be developed using "known laws of physics and fairly reasonable engineering extrapolation of known technologies."

Another method of space propulsion would utilize the power source of the stars—fusion. Unlike fission reactors, which release energy by splitting atoms, a fusion reactor fuses the nuclei of the lightest atoms to create heavier nuclei and thus energy.

Fusion's fuel is water, or more accurately an isotope of hydrogen that is found in water and called deuterium or "heavy hydrogen." Although there is only one atom of deuterium for every 6,000 normal hydrogen atoms in water on Earth, one gallon of water will contain enough deuterium to yield as much energy as is released by burning 33 barrels of gasoline.

But fusion doesn't even work on the ground yet. For nearly half a century some of the world's best physicists have tried to create a controlled thermonuclear fusion reaction in the laboratory. (They did succeed in creating *uncontrolled* fusion devices; we call them hydrogen bombs.) In 1985 a fusion experiment at the University of Rochester in New York finally yielded an energy output that was higher than the electrical energy put into the apparatus. Scientists expect that fusion power plants for generating electricity will be on the way by the turn of the century, and it seems inevitable that fusion will be applied to space propulsion.

The energy potential of fusion is so great that if it were applied to spaceflight, travel times through the solar system would begin to look like cross-country bus schedules. A fusion spacecraft could accelerate continuously at 1 G until it was approximately halfway to the target planet, then reverse thrust and decelerate to a velocity low enough to enter an orbit around the destination world. Travelers would be able to reach Mars over a weekend, Jupiter in a week.

Fusion rockets could give us not only the solar system but the nearer stars as well. A chemically powered rocket, such as that used on the Apollo missions, would take 50,000 years to reach another star. But fusion-powered unmanned probes, such as Project Daedalus, a spaceship design proposed by the British Interplanetary Society in 1978, could reach stars such as Barnard's Star and Alpha Centauri in as little as 50 years. Like Project Orion, Daedalus would have a nuclear-pulse rocket. But instead of accelerating by means of large fission explosions each second, Daedalus would gain speed from fusion micro-explosions—the equivalent of exploding very small hydrogen bombs—ignited by laser or electron beams 250 times per second within a magnetically insulated "thrust chamber."

Beyond fusion, there is one other possibility: anti-matter. In 1932 the positron—the anti-particle of the electron—was discovered, confirming the existence of anti-matter. When particles of matter and anti-matter collide, they annihilate each other, releasing enormous energy. Whereas fusion liberates 0.7 percent of the mass of the reacting matter, a collision between normal matter and anti-matter transforms *all* the mass into energy—100 percent conversion. This produces energetic particles called pions, which could be funneled by a magnetic field to create thrust.

"Realistically, we can't figure out anti-matter in less than 20 or 30 years," says Forward. Particle accelerators at CERN near Geneva, Switzerland, and at Fermilab in Batavia, Illinois, have successfully accelerated protons to nearly the speed of light, then smashed them into a target to produce anti-protons. But a million protons have to be smashed to produce a single anti-proton today. And storage presents another problem. So far an anti-proton has been stored for 10 hours, but a ship heading for the stars would have to store condensed blocks of anti-matter for years.

Even its advocates admit that at this point interstellar propulsion lies in the realm of science fiction. First comes our own solar system. We have been to the moon six times; the next new destination will probably be Mars. *When* still remains to be seen. It depends in large part on whether an Apollo-like effort is made, and then whether it's an "F^3" mission (footprints and flags first) or the establishment of a permanent outpost. As with the Apollo moon program, there is also the question of what to do when we get there. As one NASA scientist says, "We'll know that we're permanently on Mars when the residents throw the tea in the harbor."

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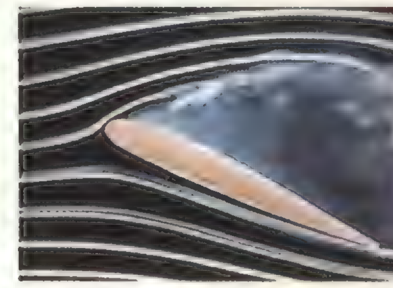

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Air Transportation Capacity: How We Lost It, How We'll Get It Back

It may be a big sky, but it's getting awfully crowded.

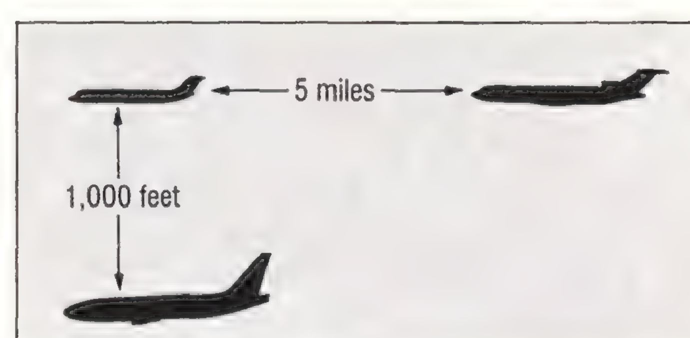
by Robert Machol, chief scientist, Federal Aviation Administration

Since the airlines were deregulated, the number of people traveling by air has doubled, yet the capacity of the air transportation system has hardly increased at all. Deregulation led to lower prices and increased demand, but it also drove most airlines to adopt the hub-and-spoke system, in which most cities on the airlines' route system are served through connecting flights at a large, centralized hub airport. Before deregulation took effect more than 10 years ago, you could get a nonstop flight between most large cities, though nonstops were few, usually flown in larger airplanes (the 150-seat Boeing 727, for example), and often scheduled at inconvenient times. Now, except for flights between the hubs, nonstop flights have virtually disappeared.

Hub-and-spoking has had two effects that exacerbate the capacity pinch: first, the airlines fly more frequently and they use smaller airplanes—the 100-seat Boeing 737—to match the passenger loads, and second, it now takes at least two flights to travel between most cities, which means additional landings and takeoffs on the same number of airport runways.

The pressure is especially acute at the hubs themselves. Atlanta, Dallas/Fort Worth, St. Louis, and Chicago-O'Hare are among the most crowded of our airports and the ones at which delays are most likely to occur. Most delays are caused by inadequate runway capacity, and that capacity is further diminished when weather deteriorates. Meanwhile, as airport capacity is being stretched, demand increases by five percent each year.

Airspace congestion is starting to back up into the high-altitude cruise portion of airline flights. Lack of airspace is more serious in Europe than in the United States, but the dedication of large blocks of airspace to military operations already hinders some parts of the western states. Areas such as the Los Angeles Basin are desperately overcrowded. Even in airspace that one might think would be fairly empty—the skies over Indiana, for example—the air is thick with airplanes using busy east-to-west and north-to-south corridors. Sometimes the number of aircraft over Indiana is so great that it is impossible to maintain the required separation of five miles horizontally and 1,000 feet vertically.



But congestion in the upper airspace may prove the easiest problem to solve. We have already made progress on the transoceanic airways, where no radar surveillance is available. Twenty years ago the separation of airplanes over the oceans was maintained by requiring each aircraft to follow its assigned flight path as closely as possible by use of its own navigation devices. Those devices were not very precise, so a lateral separation of 120 miles was the rule. Navigation has improved to the point that today the minimum separation is down to 60 miles, and in the near future it may

go down to 30. Within 10 to 15 years, we should have very accurate satellite-based surveillance over the entire ocean, and if we know where each aircraft is, separation standards can be reduced to as little as five miles. Similarly, the five-mile separation now required for aircraft en route over the continental United States may be reduced to two or three miles with better radar data and improved computers. This could expand the capacity of our airspace enormously and remove many of the current restraints.

Despite the pressure created by the increased demand on capacity, safety continues to be the overriding concern in the operation of our airports. In today's airport environment we try to separate approaching airplanes by three-mile intervals (the five-mile minimum applies only at higher speeds and altitudes). It takes an enormous amount of coordination, sometimes beginning when the flights are hundreds of miles from the destination airport, to feed airplanes coming from different directions and at different speeds and altitudes into a single line. It is simply impossible to do all this very efficiently, so the distance between two airplanes when one finally touches down is sometimes considerably greater than three miles. A new computer, part of the Federal Aviation Administration's Advanced Automation System, will enable us to coordinate much more efficiently and increase the traffic flow to a given runway.

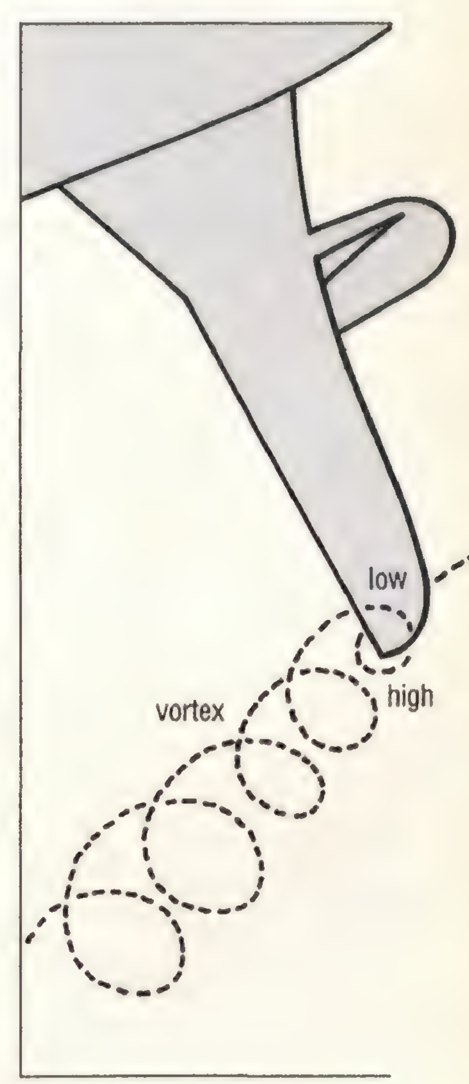
When runways are dry and daylight visibility is good enough for approaching airplanes to see one another, aircraft can be landed on closely spaced parallel runways or even on intersecting runways as long as certain rules are followed to ensure that the airplanes won't come too close to one another. People make mistakes, and in order to prevent a mistake from becoming a catastrophe, we impose rules that are quite stringent. For example, if two airplanes are landing on intersecting runways, we always assume the worst: that both will abort their landings at the same time. We therefore impose a rule that provides enough space for both airplanes to execute their missed-approach procedures safely.

When visibility is so poor that aircraft have to rely on instruments and electronic navigation aids for guidance, we permit aircraft to land simultaneously on parallel runways only if the runways are 4,300 feet apart. Twelve major airports, including six hubs, have parallel runways that are spaced closer. But at all of these, the runways are more than 3,000 feet apart—a distance most experts think would be safe for such operations, though the rules do not allow it.

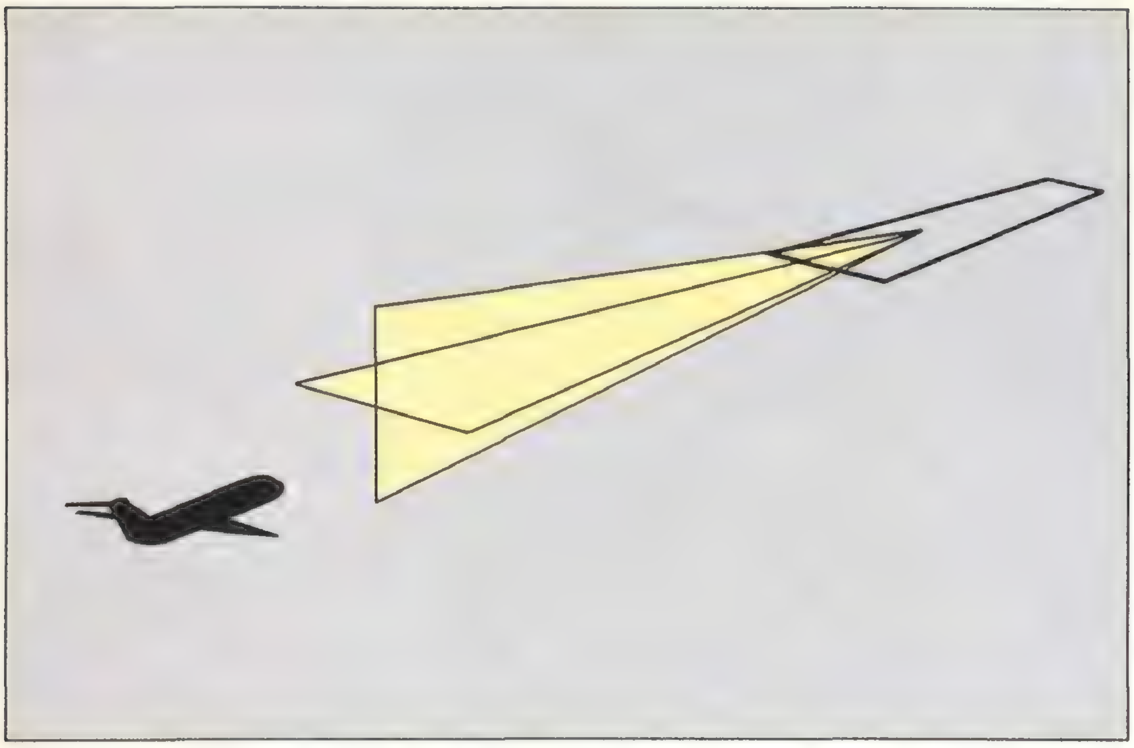
But how safe is safe? We surely cannot tolerate one accident in every million landings; there are millions of landings in the United States alone each year. Suppose we decide that one accident per 10 billion landings is acceptable. Although it's not easy to prove that a proposed set of landing procedures will provide that level of safety, it can be done using computer modeling with experimental data. Research is now under way at the Raleigh/Durham, North Carolina and Memphis, Tennessee airports, which have parallel runways spaced about 3,500 feet apart. Using new radars, computers, and displays, we'll try to demonstrate that airplanes can be controlled so precisely that bad-weather landing operations can be conducted safely with runways spaced only 3,000 feet apart. If we're successful, this improvement will probably be adopted within the next few years and should increase the bad-weather capacity by about 25 percent at the 12 airports affected.

Turbulence due to wingtip vortices is another factor that adds to the distance required to separate aircraft lined up to land. These mini-tornados stream from every airplane's wingtips due to the normal airflow from beneath the wing, where air pressure is high, to the area above the wing, where the pressure is low. A vortex from a large airplane is strong enough to flip a smaller airplane on its back. Airplanes must be separated enough to allow the vortex to dissipate, and that rule applies to both landings and takeoffs—even extending to adjacent runways, since vortices can drift. Now intensive research is under way to learn how to dissipate vortices more quickly. Some experts doubt the effort will be successful, but if it is it could lead to significant improvements in capacity.

Other technological improvements are more certain, and they will be available soon. The current precision navigation aid for landing guidance is called the Instrument Landing System, or ILS. The system consists of two very precise radio beams, one aligned with the runway's centerline and the other aligned with the desired glide path to the touchdown point on the runway. The pilot flies along the center of both beams to a landing. Some ILS systems are so precise they can safely be used when the pilot cannot see the runway at all. But there are drawbacks: the alignment of ILS beams can wander due to moisture and precipitation or reflections from buildings or aircraft, so they must be checked frequently. And some airports have terrain problems that

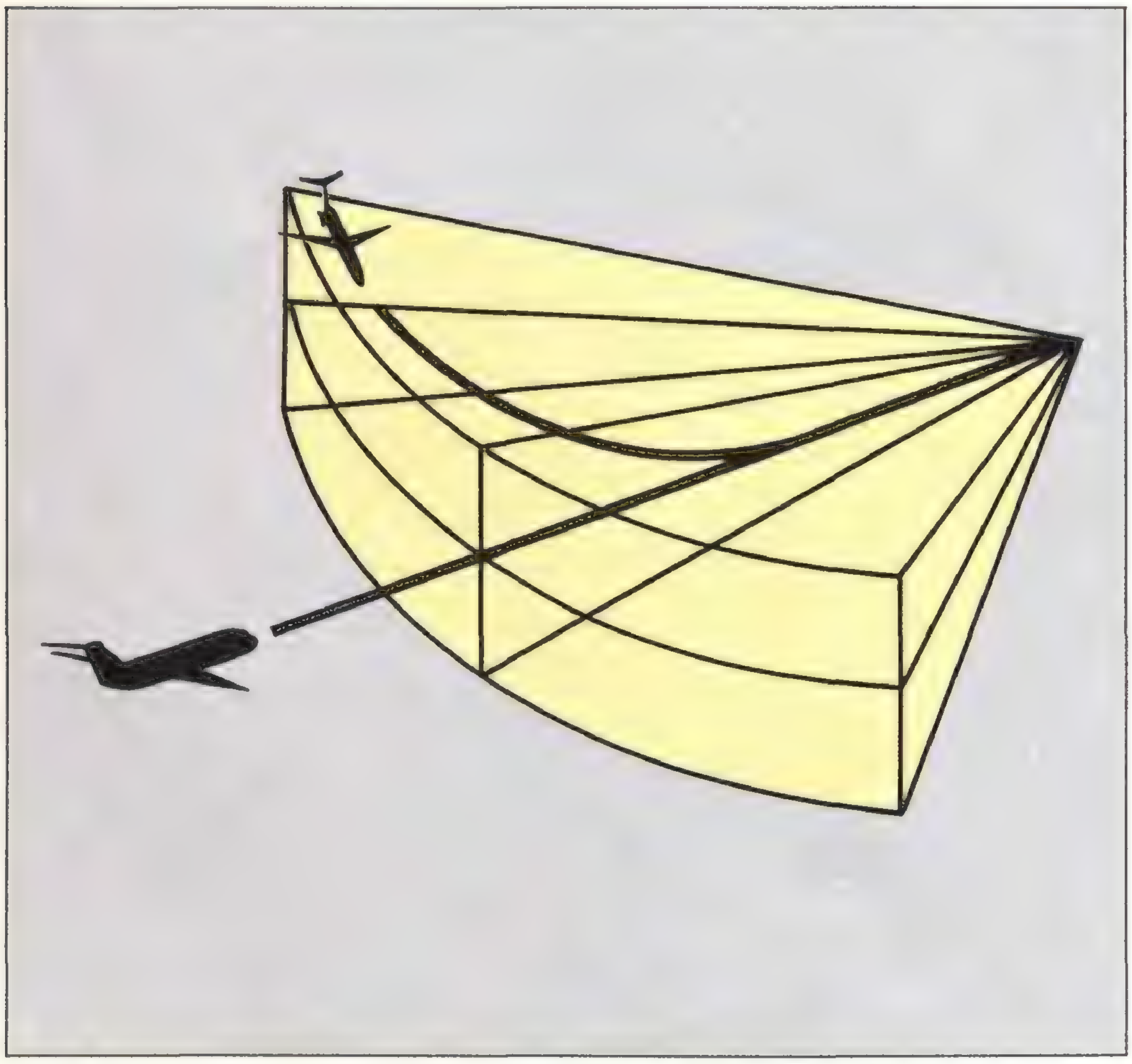


Trailing vortices form on wingtips when high-pressure air below the wing, attempting to reach the area of low pressure above the wing, curls around the wingtip. These powerful vortices can flip a nearby aircraft on its back, so adequate spacing between airplanes is essential.



The Instrument Landing System, while exceptionally precise, provides only a narrow approach pathway.

The new Microwave Landing System offers a much wider area of precision navigation coverage and multiple pathways for aircraft.



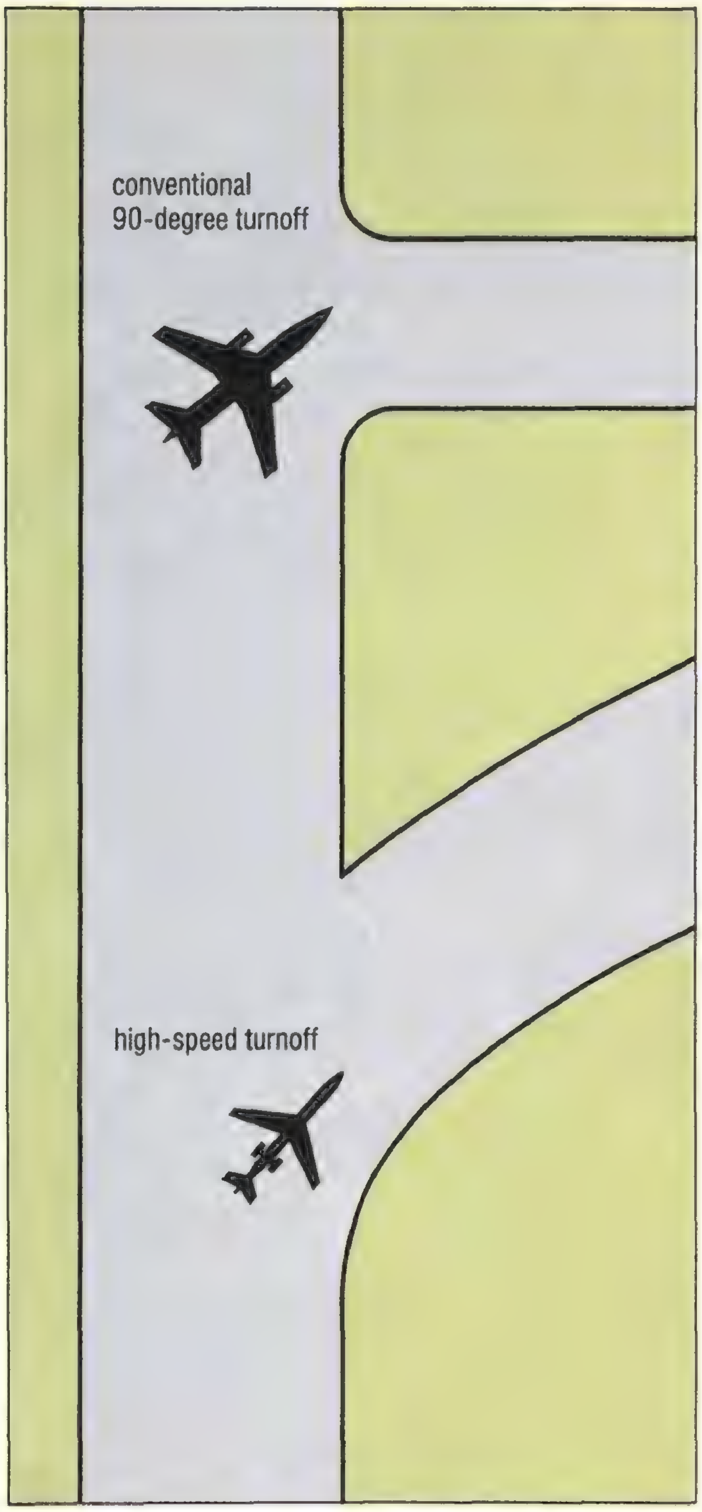
prevent installation of an ILS.

The Microwave Landing System is a new and entirely different concept that will replace the ILS. Instead of two fixed beams, the MLS transmits two beams that sweep back and forth with extremely precise timing. By clocking the exact moment at which each beam strikes the airplane's receiving antenna, a computer aboard the airplane can determine just where the airplane is with respect to the runway centerline and glide path. A third component of MLS provides a measure of the distance between the airplane and the runway, thereby fixing the airplane in space in three dimensions. With ILS, all approaching airplanes must line up along the beams' centers. But with MLS, a number of approach paths become available simply by instructing the computer to seek a different time interval between the sweeps of the beam.

There are also a number of small improvements that individually would not make a big dent in the capacity problem but together could help a great deal. For example, once an airplane lands, it must quickly clear the runway and taxi to the gate. Most exits from runways to taxiways require 90-degree turns, and airplanes must slow to a near-stop as they turn off the runway. A safety rule prohibits an airplane from landing until the airplane ahead of it has exited the runway, so controllers maintain a generous interval between airplanes in order to minimize conflicts. If the exit from the runway is set at a shallow angle, like exits on our highways, the pilot can turn off while still rolling at a considerable speed. The controller can reduce the interval between airplanes, and that same runway is then able to handle many more aircraft each day. Such high-speed turnoffs are being added at many airports.

Frequently, airplanes must cross a runway to get to the gate, and in bad weather, when the tower controllers can't see well, it is difficult to issue taxi clearances quickly and safely (the worst accident in aviation history occurred at Tenerife in the Canary Islands, when a 747 taking off collided with another 747 taxiing across the runway). But new technology will help here as well. New radars and infrared sensors to monitor aircraft and ground vehicles are being developed, and even more sophisticated systems that include such things as pressure sensors in taxiways and runways may someday allow us to reliably pinpoint the position of all surface traffic when visibility is obscured.

But the surest way to achieve a significant improvement in capacity is to add more



concrete—new airports and new runways at existing airports. Additional runways are being added at some airports—Atlanta is getting one for commuter airliners, Washington Dulles is planning two more, and Detroit is adding one—but environmental constraints and political opposition from citizen groups concerned about noise make it nearly impossible to get such additions approved. Moreover, they are quite expensive.

Only one major new airport has been built in the United States in the past quarter century: Dallas/Fort Worth Regional Airport, which opened in 1973. And only one major new airport—Denver's new 50-square-mile complex—is planned for the next decade. But dozens of the nation's airports are being underutilized; Oklahoma City's and Milwaukee's are two examples. There had been talk of building a high-speed rail line linking metropolitan Chicago with the airport at Milwaukee to relieve the pressure on O'Hare and Midway, but the economic analyses were discouraging, and the demand on Milwaukee has recently increased to a point where the idea is no longer valid. The discussions concerning an additional major airport for Chicago near the Illinois-Indiana border have finally progressed to the point where such an airport now appears probable around the year 2000. Some exciting new ideas are being proposed for this airport, including the possibility of private financing.

The airlines could begin to move away from the overcrowded hubs and use less congested airports. American Airlines has made Raleigh/Durham, North Carolina, a hub airport, and Piedmont (now part of USAir) did much the same thing at Dayton, Ohio. New airports could also be constructed in places that are neither origin nor destination cities—so-called non-O&D hubs. At O'Hare, half the passengers passing through are there only to make a connection; at Atlanta's Hartsfield, the figure is 70 percent. Constructing new hubs out in the boondocks where O&D passengers may make up less than five percent of the traffic could make it difficult for the airlines to operate at a profit without the passengers a large O&D city generates. On the other hand, the airport may be cheaper to use if the land is inexpensive and there are fewer neighbors to complain about the noise.

We may get such hubs in the future if the capacity squeeze renders the existing airports unprofitable. Delays are expensive for an airline. If an airplane is an hour late in the morning, it will be an hour late for the rest of the day. Passengers who miss connections may switch to another airline or get stuck overnight, incurring expenses the airline may have to pick up. Delays increase crew costs, consume fuel, and may cause flight cancellations. These pressures are already moving the airlines toward larger new airplanes like the 200-seat 757.

Designing an airport to move people between airplanes rather than to get people to rapid transit or parking lots is a fascinating challenge. One new concept is the "superport," a non-O&D hub that could be built near a coast to serve transoceanic traffic. One could go in southern New Jersey or Delaware, and another might be located in Oregon or in the desert east of Palmdale, California.

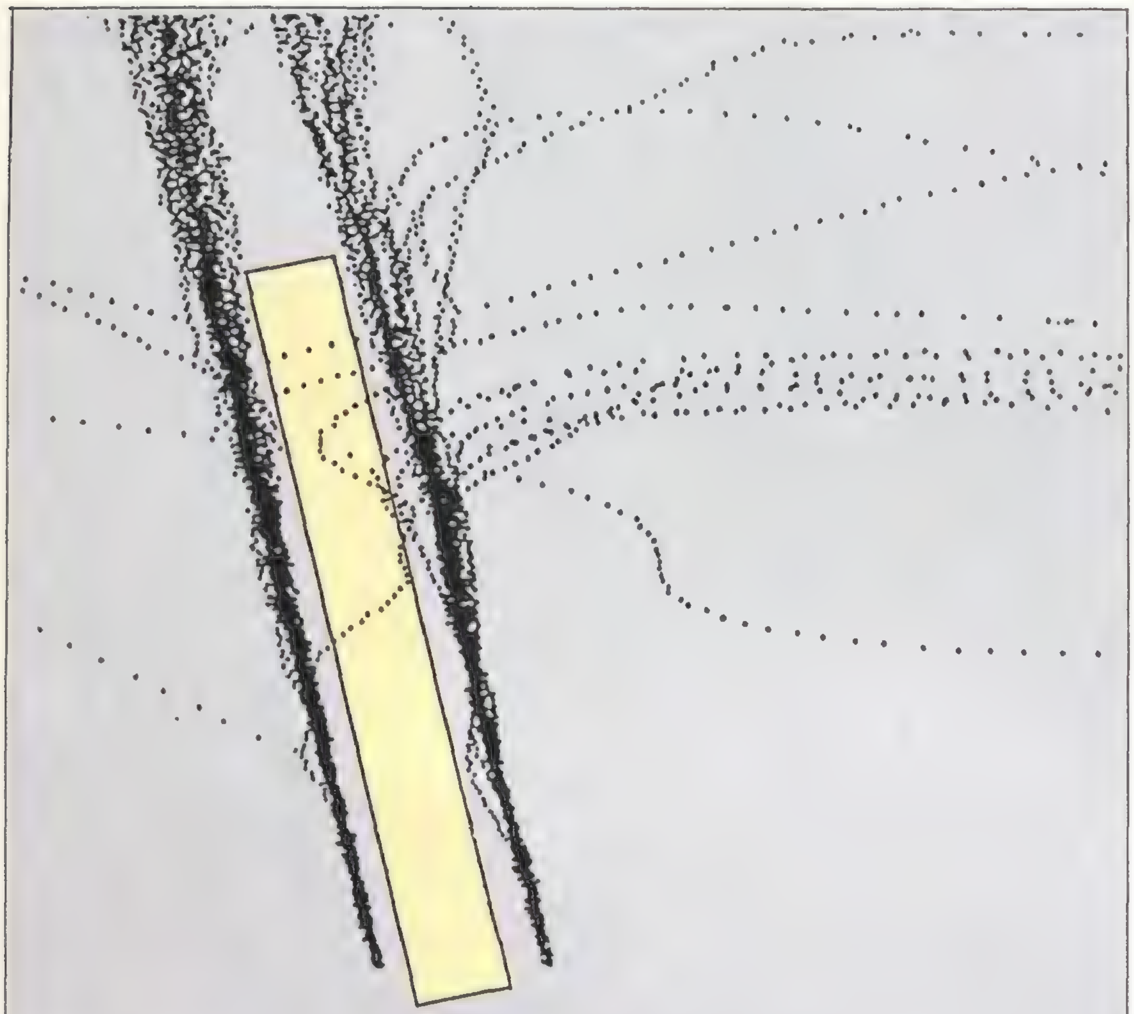
Such superports would be better able to handle supersonic transports, which require special procedures at conventional airports to

minimize their noise. The SST can fly supersonic only over the ocean, so a coastal site makes sense. Within the next decade, the High Speed Civil Transport, an airplane designed to fly at between 1,800 and 2,500 mph, will be built in the United States, and such airplanes will need special handling. They burn too much fuel to permit delays aloft, and their surfaces will be hot after landing due to atmospheric friction, which means we'll need new ways to deplane passengers and baggage. Some portion of a superport could be dedicated to the handling of such aircraft, and efficient handling on the ground could play a major role in making the airplane economically viable by speeding the turnaround time between flights.

Superports could also be designed to handle much larger airplanes than we have in service now. The largest 747 can handle up to about 500 passengers when the seats are closely spaced. Boeing has stretched versions on the drawing boards now, but many airports could not accommodate their weight and size. There is no reason why a superport could not manage 1,000-passenger transports, which would be more efficient and probably lead to lower fares.

Regulation is one way to alleviate capacity problems. At Boston's Logan Airport, a controversy arose when a rule was established discouraging small airplanes from landing there. The airport management argued that more people could fly in and out of Logan if small airplanes carrying few people were replaced by larger airplanes carrying more people, so it increased the landing fees for small airplanes and decreased the fees for large ones. There are two arguments against that pricing policy: first, people from small towns should not be penalized because they have to fly smaller airplanes to Logan in order to board larger airplanes for their final destinations, and second, people who fly small aircraft have an equal right to access. If a policy like Logan's were applied to automobiles on our interstate highways, we might cut down on traffic but there'd be a political uproar. In the long run, regulation does not solve any problems.

In *Through the Looking Glass* Alice says to the Red Queen, "In our country you'd generally get to somewhere else—if you ran fast for a long time." "A slow sort of country," responded the Queen. "Now here, you see, it takes all the running you can do to keep in the same place." This nation's air transportation system is doing all the running it can do. It handles 10 times the number of passengers it transported at the beginning of the Jet Age, in much faster airplanes and with one-tenth the fatality rate. Our economy and social well-being depend on safe, reliable, timely passenger and cargo aviation services. With courage, foresight, ingenuity, and the willingness to spend some money and make some compromises, we should be able to manage the anticipated threefold growth in air service in the next two decades and still "keep in the same place." It is worth a try.



Test Case

This plot, made on January 29, 1989, represents radar data recorded during the approach of 57 aircraft between the hours of 2:30 and 3:50 p.m. at Memphis, Tennessee's runways 18 Left and 18 Right. These parallel runways are separated by approximately 3,400 feet. Between their approaches is a No Transgression Zone—the NTZ—a long rectangular area between approach paths that measures 2,000 feet in width. Weather conditions were described as a 200-foot overcast with one-half-mile visibility in fog and light rain; wind from 20 degrees at three knots. Each dot represents one reply by an airplane's radar beacon transponder, which transmits in response to an interrogation by a special Mode S radar. The dots are spaced 2.4 seconds apart. Both runways are a short distance below the point where the dot pathways terminate and radar data is lost. Some diverging pathways represent aircraft executing missed approaches. One aircraft was directed from the left runway to the right (the S-shaped path through the NTZ). In no case do aircraft on final approach encroach upon the NTZ, and according to FAA officials, most plots made in instrument weather conditions are similar, though the paths are not quite so precise in strong winds. The data strongly suggests that more closely spaced parallel approaches are safe.

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*Based on *Car and Driver* test results. Buckle up for safety.

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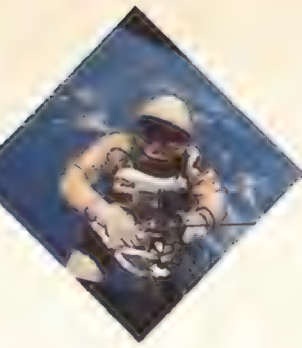
A Permanent Presence:  **First in a Series**

Although the settlement of space is at least a decade away, NASA is making plans for the journey outward.

This series of articles will report the steps being taken to make space a permanent address.

The Blue Collar Spacesuit

Two suits are competing to get aboard the space station, where proper attire is required for survival.

by John Grossmann

Such are the ways of the National Aeronautics and Space Administration that before a new spacesuit can fly, it must first sink. "It's a bit like qualifying an F-16 to be a submarine," says Vic Vykukal.

Today's dunking, at NASA's Ames Research Center in Mountain View, California, will afford a last round of testing before Vykukal (pronounced "vick-a-call"), principal engineer in crew and human factors research, takes apart his AX-5 suit, packs it up, and sends it off to the Johnson Space Center in Houston, Texas. There it will compete head to head (and shoulder to shoulder, arm to arm, and leg to leg) in far more extensive testing with the Mark III, a spacesuit of considerably different design.

Of the two competitors, the AX-5, nicknamed the Michelin Man because of its eye-stopping assemblage of segments, is more radical. There's not a stitch of fabric in it. Head to toe, it's harder than a turtle shell. The Mark III blends hard elements with more traditional soft goods. It hails from across the continent—specifically, the tiny town of Frederica, Delaware, home of a private company called ILC Dover, Inc., which has designed and built it in partnership with the Johnson Space Center.

Each design, years in development, is vying to be the astronauts' new clothes, a blue collar spacesuit that sometime around the middle of the next decade will help build space station Freedom and thereafter clock eight-hour days, week after week, on various projects in space. The Michelin Man is the underdog. Lockheed, the company ultimately responsible for supplying the station spacesuit, is planning to use a suit "very similar to the ILC hybrid" as the basis for the manufacturing contract, according to Joseph Kerwin, a Lockheed manager. Kerwin also says that Lockheed will feed the results of the Johnson review of both spacesuits into the contract requirements.

But first comes the water. At the Johnson Space Center there is a huge tank, a 500,000-gallon swimming pool known as a Weightless Environment Training Facility—WETF (pronounced "wet if") for short. Here at Ames, what's sometimes referred to as "the hot tub" is more modest. The raised tank, walled with observation windows, is nine feet deep, 11 feet in diameter, and holds 5,000 gallons. Somebody has stuck on a sign: *Beware of sharks. Swim at your own risk.*

The man in the white metal suit is Vic Vykukal, designer of the first all-metal spacesuit (right).

Playing dunk the designer, an Ames human factors research team tests spacesuit comfort and mobility.

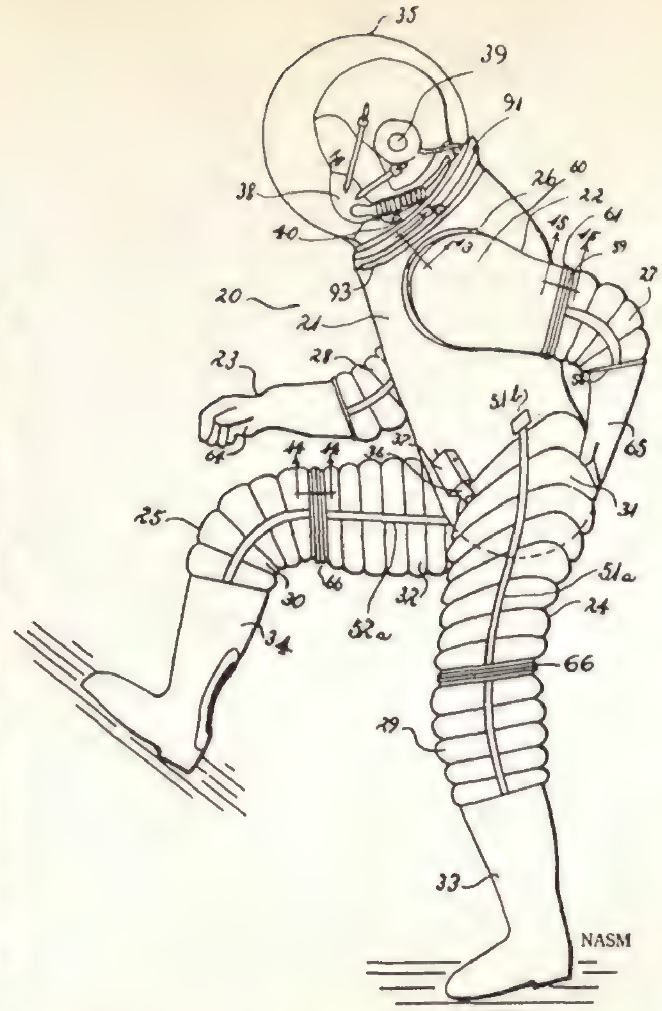
ROGER RESSMEYER-STARLIGHT (2)

The idea, of course, is to have water stand in for space: buoyancy in the tank simulates microgravity. On this March morning, there's another stand-in. One of Vykukal's assistants, a suit designer named Phil Culbertson, is preparing to enter the tank. He's wearing astronaut longjohns, otherwise known as a liquid cooling garment (plastic tubes circulate cool water throughout), as well as accessories that are not standard issue: skateboard knee pads and volleyball elbow pads. He climbs the stairs to the lip of the tank.

Until now, astronauts have pulled on their pants like firemen and then wormed their way up and into the top half, which is held in place by a frame. That's about to change.

Stepping up five more stairs, Culbertson reaches the AX-5, which hangs suspended from a gantry hook, toes just off the tank platform. The hinged suit back yawns open in a square hole that is tilted a helpful 9.5 degrees forward of vertical. Feet first, a bit like a child at the top of a slide, Culbertson slips in. The rear door closes like a re-

NASM



NASM

Wiley Post's 1934 pressure suit evolved into a more flexible version after designer Russell Colley was inspired by the inching of a tomato worm.

Patented in 1943, the "tomato worm" designs showed up later in the Mercury spacesuits (below), which were aluminized to reflect heat.

NASA

frigerator and is latched shut for him. Next comes his helmet. Life support switched on, communications working, Culbertson hangs like a marionette, flexing his arms and legs. All ready. The gantry groans, and soon, calling to mind Indiana Jones suspended over a pit of boiling lava, he's poised above the tank. Slowly, down he goes.

I think it's more of a competition than some fellows are willing to admit.
—Bruce Webbon, Ames research chief

It's a competition of ideology and engineering philosophy. We're hell-bent to beat Ames.
—Homer Reihm, ILC president

Whether a hard suit or a semi-hard one emerges victorious from the big tank at Johnson Space Center, it will be a very different outfit from today's style, the shuttle suit. It must be. The shuttle suit is not the panoply for hundreds of eight-hour days in a life-threatening environment. Built for the relatively short periods of a shuttle flight, it requires too much maintenance to offer astronauts long-term protection against micrometeoroids, radiation, and corrosive chemicals. And because station-based astronauts will be working near delicate external sensors, their suits, unlike previous models, will have to manage waste gases such as carbon dioxide internally. There will be no venting allowed. Finally, according to many of its wearers, the shuttle suit is a pain in the neck, as well as the shoulders, the arms, and so on.

"You're never unaware of being in it," says former astronaut Brigadier General Robert Stewart, now deputy commander of the U.S. Strategic Defense Command. Stewart experienced, or rather endured, two periods of extravehicular activity (EVA) in the shuttle suit a day apart in February 1984. "You're constantly shifting positions to try and get a little extra motion. And if the suit is fit properly, you're kind of wedged into it. The pressure points for me were the collarbone and the finger-

Stiffened into immobility by the suit that kept him alive, Ed White took a tethered space tumble in 1965.

NASA

tips of the glove. I experienced bruises on my shoulders and my fingertips, and my nails got a bit discolored. My first EVA I worked so much with my hands—and at that time was using an earlier version of gloves—that my forearm muscles were just about in knots by the time I finished."

"The shuttle suit has certain ways," explains mission specialist Kathryn Sullivan, speaking like a patient parent accounting for a child's occasional mulishness. "It does not have all the same ranges of motion that your body has. Its shoulder is not like yours, and its knee is not built like yours, so you learn, through several runs in the water tank, a whole set of lessons that have to do with suddenly being a person of greater mass and volume. For instance, you can't put your nose right up to something.

"But ours is not a recreational job," she adds. "This is not sailing the South Pacific for fun and a tan. The vacuum of outer space is a tough and unforgiving environment, and there's no escaping the reality: you have to be isolated from this environment to survive it."

As even ground-bound mountain climbers know, the human body, which no doubt evolved at or pretty near sea level, starts sputtering when the air begins to thin. Above 38,000 feet, most people lose consciousness in 30 seconds without a supply of oxygen. In the near vacuum of space, gas in the lungs would expand, preventing respiration. And without a device to supply pressure, body fluids would vaporize.

Survival, not comfort, has historically determined the design of these devices. For a series of high-altitude tests in 1934 and 1935, Wiley Post used a suit that was contoured in a sitting position. Once it was pressurized he couldn't stand straight or walk. Accounts say "it afforded some degree of mobility in handling the airplane's controls." Alan Shepard's Mercury suit offered insurance, the ability to function as a backup in case of cabin depressurization. Its primary requirement sounds ironic today: it had to be comfortable *un*pressurized.

The difficulty of moving in a pressurized suit was dramatized in 1965 on the first spacewalk. Cosmonaut Alexei Leonov's spacesuit expanded so much during his walk that it took him eight minutes to get back inside the airlock of his spacecraft—every movement was an effort. Three months later, when Ed White tumbled out of the Gemini 4 spacecraft, he looked like a balloon in the Macy's Thanksgiving Day parade. "If you've ever seen any film of him, you know how immobile he was," says George Durney, ILC's chief engineer, a somewhat crusty veteran spacesuit designer whose white hair is cut in a mid-century crew.

"God had a hell of an advantage. He put the joints on the inside," says Durney, explaining that the quest is still to provide full range of motion through an external shoulder or knee joint, without undue effort from the wearer. Picture a cylindrical balloon, one of those frankfurter-shaped jobs. Inflated slightly, it's easy to bend, but with increasing inflation it takes more and more effort to reshape it. On top of their liquid cooling garments, astronauts wear a kind of balloon—a rubber body suit, or gas bladder—that provides the desired pressure. But the rubber is highly elastic and, without a second skin to contain it, would merely expand under the pressure. Trying to duplicate the geometry of human bone structure externally in this second skin, which ILC has traditionally fashioned of specially patterned and reinforced polyester, has repeatedly sent Durney's fingers scratching his crew cut. "If you could just put pins through a guy's shoulder or

The manned maneuvering unit and shuttle suit enabled Bruce McCandless to display grace under pressure.

NASA

Suitable attire for a 1972 stroll on the moon was the A7-LB, the first suit to take the yank out of sitting.

elbow," he muses, "it would be a whole lot easier."

Durney has produced more humane solutions. One of the suits he is proudest of is the A7-LB, which improved neck mobility and thus visibility for Apollo astronauts driving the Lunar Rover. Another improvement was an "automatic" waist joint that took the yank out of sitting. Prior to the new joint, an astronaut had to tug and fasten a chest-mounted strap simply to sit down. To stand, he pulled again on the strap and released it.

The A7-LB proved nimble enough that ILC shot some 16-mm film of a systems engineer named Tom Sylvester wearing it on a high school football field. After a round of jumping jacks, toe touches, and pushups, Sylvester tried his hand at making a few tight-end-style catches and his foot at punting and field goals. Hardly the stuff of NFL highlights, but his 20-yard kick through the uprights is still memorable.

The shuttle program, which opened the hatch to women, ushered in other changes in tailoring. Apollo astronauts and their predecessors wore custom-made suits. But for most of this decade, astronauts have been dressed like roommates getting ready for Saturday night—their suits were assembled off-the-rack, torso off this hanger, legs off another, arms, boots, gloves, from surely the most expensive clothes closet in the land.

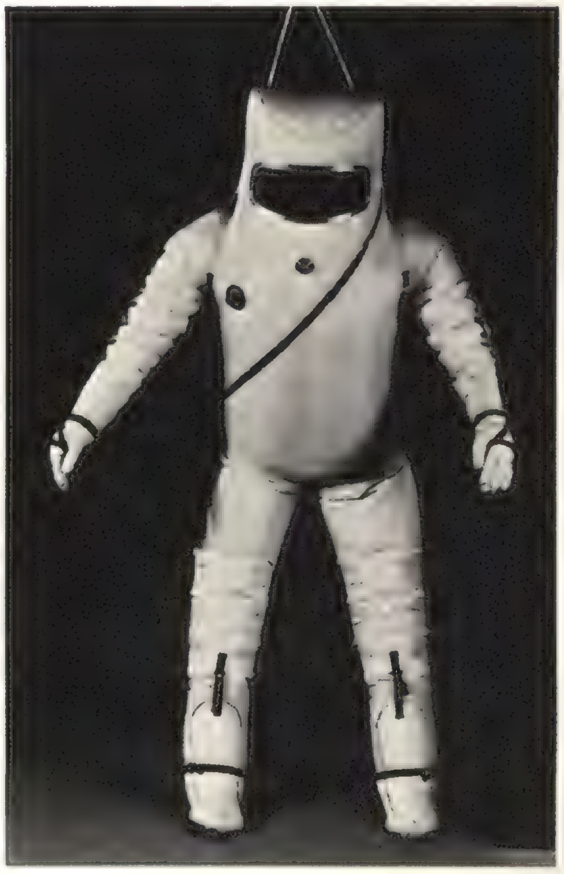
Years back, simply out of curiosity, Durney tracked the cost of a production-model Apollo suit. "By the time you added in all the paperwork, it came to about 250 a copy." He nods. "Yes. Two hundred and fifty thousand dollars." Estimates for the eventual cost of the space station suit run several times that. Costs in general, and paperwork in particular, have risen through the years. But spending more on the suit may reduce costs in other operations.

A key requirement of the space station suit is onboard maintenance and servicing. That's no small matter, considering the current protocol for a shuttle suit returning from a mission. By the time the suit has been inspected stem to

NASA

In 1960 the Republic Corporation proposed the "tripod teepee," a failed forerunner of Vykukal's canned-man approach. It would have claimed a lot of room on a spacecraft. Another suit that never flew, the Anthropomorphic Rescue Garment, was designed by ILC in 1978 for the orbital transfer of an astronaut from a disabled shuttle.

NASM (2)



stern—checked for pressure leaks, its backpack life support system readied for the next flight—some 2,700 to 3,000 man-hours have elapsed. Aboard the space station, inspecting the suits will be the astronauts' responsibility, though they'll get a big hand from automatic checking systems and easily replaceable units.

In this corner, weighing 185 pounds, the challenger: "Michelin Man." Rotating bearings in the joints imitate the human range of motion.

ROGER RESSMEYER-STARLIGHT

But by far the biggest savings—and the biggest challenge—has to do with increased suit pressure. NASA has long batted around the notion of a "zero prebreathe suit," or ZPS. With good reason. The present discrepancy between the one atmosphere or sea-level pressure of the shuttle cabin (14.7 pounds per square inch) and the pressure inside the shuttle suit (4.3 psi) currently squanders a precious commodity: an astronaut's time. Nobody's time is as costly as an astronaut's in space, but a shuttle crew member preparing for an EVA essentially idles, expensively, before getting dressed.

What's he doing? Breathing 100 percent oxygen during a so-called "washout" period to remove nitrogen gas dissolved in body tissues. As a scuba diver returning too quickly to the surface can suffer the painful and potentially lethal effects of the bends, so can an astronaut at the onset of EVA, if he changes pressure too drastically. One remedy is to decrease the cabin pressure from 14.7 to 10.2 psi for 12 hours before EVA and then have the EVA crew members prebreathe 100 percent oxygen for 40 minutes. With the lungs acting as a gas separator, that procedure effectively rids the body of nitrogen. But lowering the overall cabin pressure for the EVA crew members is an option only when there are no pressure-sensitive experiments on board. Furthermore, the less dense air is more difficult to cool, raising some concern about temperature-sensitive instruments and controls. In order to prevent these problems, NASA prefers to keep the cabin pressure constant and have the EVA crew members prebreathe 100 percent oxygen—for three to four hours.

Wouldn't it be nice to have a higher-pressure spacesuit that would eliminate the need for prebreathing, make EVA missions more routine, and, not so incidentally, offer quicker response time in an emergency? Calculations show a suit pressurized to 8.3 psi—nearly twice the pressure of the current shuttle suit—would fit the bill. That, however, is like saying you'd have more office space in a mile-high building.

"The new suit is an enormous leap," says Philip Spampinato, ILC's advanced development manager. "You cannot use the same technology. It's akin to the challenges of breaking the sound barrier—components that work fine at 500 miles per hour must be beefed up and changed entirely to withstand the turbulence of Mach I. Double the pressure in the suit and the design challenges go up exponentially."

I'm not biased against fabric, just against using fabric to do the wrong job. Space station will mean a whole new set of requirements.
—Webbon, Ames

There's more than pride at stake. Ours is the right tool. Theirs is not.
—Spampinato, ILC

Encased in the AX-5, Culbertson touches bottom in the Ames hot tub and soon works his boots into the awaiting foot restraints. In his bare feet, Culbertson stands five foot ten, about average astronaut height these days. To get a good fit from the AX-5, he has fixed three sizing rings above each knee and four below. These rings come in five sizes, ranging from 0.46 to 1.46 inches high, and, when inserted in all manner of combinations into the suit's legs and arms, should be able to accommodate about any size crew member with the exception of a Kareem Abdul-Jabbar or Mary Lou Retton. (Ames has a photo of two employees standing side by side in the AX-5. The photo is fudged, since there's only one prototype, but the demonstration is real. The man inside the suit is six foot four and a half; the woman, five feet. Only the sizing rings are different.)

Peering in the water tank through various windows are Webbon, Vykukal, and "aerobics instructor" Becky Williamson, a research physiologist at Ames. She proceeds to coach Culbertson through mobility testing movements: forward torso bending using ankle, knee, and waist; inboard chest reach (both arms); straight leg hip flexion; and hip abduction. Inside his gleaming white, segmented shell, joints maneuvering by revolutions of bright red bearing rings, Culbertson moves a bit like a physical therapy patient relearning to use his limbs. There's a certain gawkiness, an appearance of programming some moves, but nothing like the jerkiness of the robots in science fiction movies. The AX-5 does, in fact, have a certain robotic look to it. But its human contents are apparent from the battery of computer-assisted equipment stationed outside the tank—equipment that measures the flow of oxygen into the suit and carbon dioxide out of it and calculates metabolic rate.

"We're getting some work out of you," Webbon says through his headset to Culbertson, by now well into his exercises. "We're up to 1,727 BTUs [British thermal units, each equivalent to about 250 calories]." That's roughly half the heat put out by somebody playing racquetball.

Such measurements, taken in the Johnson WETF tank and also under weightless conditions aboard a KC-135 aircraft, coupled with point-by-point recommendations made by the astronauts who test-wear the suits, will help NASA officials judge the performance of the AX-5 versus the Mark III. The two

And in this corner, weighing about 155 pounds (without its thermal overgarment), the "zero prebreathe" Mark III. It is 65 percent metal.

ROGER RESSMEYER-STARLIGHT

share certain design features: rear entry, a bubble helmet with better visibility, stainless steel bearings, and Ortman rings for coupling and de-coupling suit segments. But there are many elements to compare. Discounting agency politics, the competition boils down to a rivalry of engineering philosophies. To oversimplify, it's a contest of hard versus soft. ILC and the Johnson Center acknowledge that higher suit pressure requires more rigid construction, especially in large segments such as the torso and brief, but they believe fabric can still do the job in the joints, theoretically enhancing mobility and comfort. Ames, which is chartered to explore innovative technologies, thinks it's time for an all-hard suit and claims its design has numerous advantages over the Mark III.

For one thing, the suit's impervious skin would provide both gas bladder and containment structure—and possibly, perhaps in the form of a double-hulled, insulated construction, built-in micrometeoroid protection as well. Thermal protection, too, might be inherent, thus banishing the traditional overgarment, a cumbersome affair similar to the lead blanket a dentist lays over your torso before he departs to take X-rays. The plan is to paint the suit with a thin coating that would reflect the sun's heat—in space, sometimes upwards of 300 degrees Fahrenheit. Gold is the coating of choice, but Fort Knox needn't worry over its stash: about two and a half ounces should do the trick.

The AX-5 prototype is made of aluminum and weighs about 185 pounds (roughly 80 pounds more than a shuttle suit), but switching to a lighter metal such as titanium could subtract a few pounds. Aluminum or not, Ames says its suit will be durable, comfortable, easy to inspect after an EVA, and no mystery to manufacture.

"This new blue collar suit should be an anvil, something you don't think about, you just use," says Webbon. "If you do the geometry of the suit properly and have bearings with low enough torque—and Vic has spent years on this—the manufacturing process is very cheap and very repeatable. It's all standard engineering practices. You just put it on a lathe. There's no black art in it."

ROGER RESSMEYER-STARLIGHT

You have to bend and stretch to reach for the stars. It's a little easier in this Mark III than in the shuttle suit.

"With an all-hard suit you can use standard aerospace inspection techniques," Vykukal adds, "like pressurizing it to one and a half times operating pressure. You wouldn't have to minutely inspect it to see if any stitches are coming loose or tear the suit down to see if the bladder inside is worn. Onboard inspection is going to have to be easier aboard space station."

Even ILC, whose suit assembly room contains rows of sewing machines, admits the amalgam of special patterns, tucks, and folds of its garment tailoring is an art, not a science. However, ILC engineers see merit, not demerits, in their creative use of soft goods. Soft, let's now acknowledge, is something of a misnomer, for by the time the Mark III is pressurized, it feels far more like a car tire than a pair of pajamas. Nonetheless, ILC claims a comfort advantage for the Mark III, pointing to the ad hoc padding—volleyball and skateboard pads—now sported by AX-5 wearers in an at-

tempt to cushion the brunt of metal on bone. Ames researchers say these won't be necessary in microgravity.

Another touted advantage of fabric is the so-called "override" capacity. A hard suit, explains Joe Kosmo, Mark III project engineer at the Johnson Space Center, unavoidably provides a "hard stop." A metal joint moves only so far, then metal abuts metal.

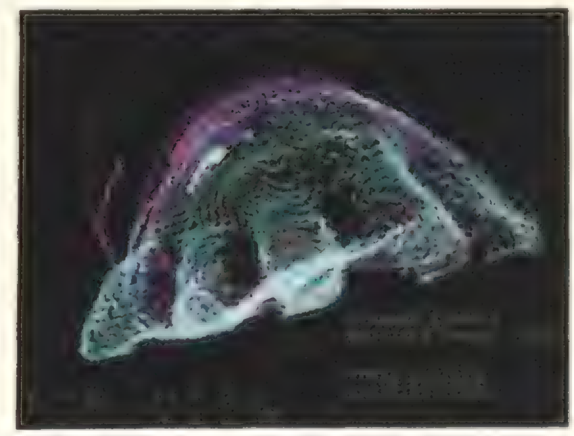
With a prop in his ILC office, Spampinato demonstrates the fabric advantage. The cylindrical model of a shuttle suit knee is fashioned of accordion-like folds similar to those found at the midsection of articulated buses. A hand on each end, Spampinato compresses the knee into a giant elbow macaroni. Then, exerting more force—the override—he bends it still further. "You'll notice, however, that it's a one-way joint," he says. "There's not enough fabric on the underside for the knee to bend the other way."

When Vic Vykukal designed the very different joints on his AX-5 suit, he had in mind the wood-burning stove in the farmhouse where he grew up. "Think of a stovepipe joint," he says, explaining that he basically improved upon the hardware store thingamajig for joining straight sections of stovepipe in angles.

Culbertson, who is about to move on to Phase II of his tasks—simulated EVA maneuvers such as "tube crimping in three orientations" and "ratchet wrench torquing"—owes his mobility to the bearings Vykukal carefully positioned between thingamajigs. It's the rotation of these bearings, through complementary planes, that moves the AX-5 joints.

"We're ready for Playschool 303," says Webbon as Culbertson faces his task board, a panel that resembles nothing so much as a baby's crib toy. The board presents Culbertson with cranks to turn, aluminum tubes to crimp with a pair of shear-like pliers, and an assortment of holes through which he must pass similar shaped boxes. Everybody's favorite task seems to be no. 6—peening aluminum. Slugging away with a hammer, Culbertson starts bending a sheet of aluminum over a mounting block. The hammering requires a good bit of arm movement, and progress is slow. "You realize," jokes Webbon, "that if you drop that hammer you'll have to catch it on the next orbit."

ILC DOVER (2)



Using lasers to scan the astronauts' hands, ILC Dover will form high-fidelity models based on 20,000 bits of data. Engineers will then fit pieces of fabric to the models. The finished gloves will have ribbed convolutes—ring-like ridges—at the finger joints and a complex structure of interlocking diamonds and squares in the palm.

The early feedback from those who *have* orbited and also spent some time underwater in the new spacesuits is a mixture of praise and concern. Astronaut Jerry Ross, a veteran of two shuttle missions, put both the AX-5 and the Mark III through some preliminary underwater paces. "Overall, they've done a pretty good job with both suits," he says, mentioning first that they're easier to get in and out of.

Ross also praises better mobility in both suits, which permitted him to nearly touch his toes, an improvement over the somewhat arthritic shin-only touch afforded by the shuttle suit. On the down side, he reports some discomfort in the AX-5, especially centered on the kneecap, and an unexpected awkwardness common to both suits. "Unlike the shuttle suit, neither of these suits has a waist bearing for rotating around the vertical axis," he says. "You can rotate some, but the rotation comes from the bearings in the legs and upper thighs. You actually have to squat a bit, so it's a little awkward and definitely more work."

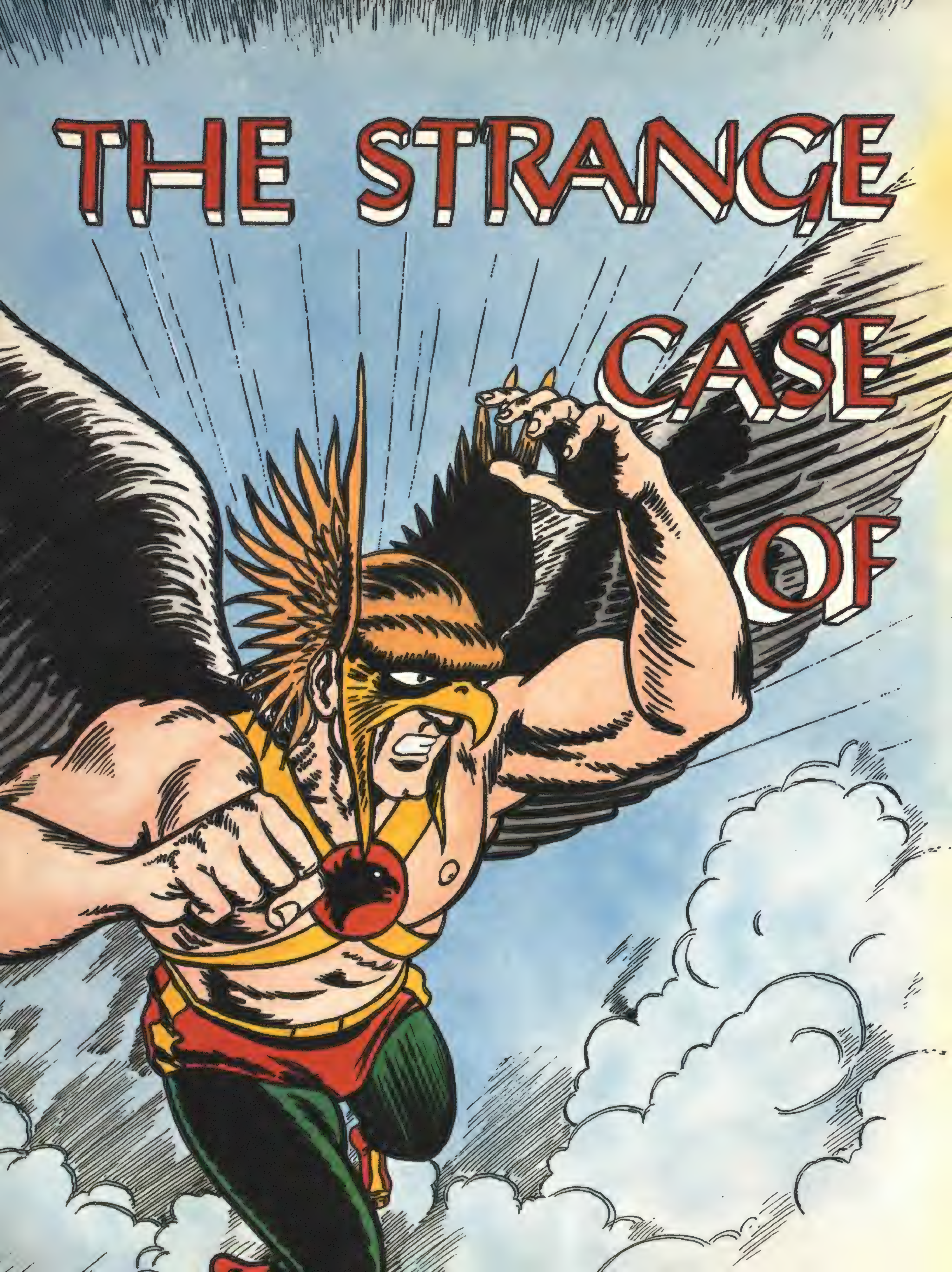
It's his opinion, and the belief of almost everyone else—both Vykukal at Ames and Spampinato at ILC, for instance—that when all the astronauts' evaluations are considered and the official test data evaluated, probably sometime this fall, NASA will most likely *not* choose either the AX-5 or the Mark III. "I think we'll probably end up with a hybrid combining the best elements of both suits, and even then I'm sure we'll see some additional tweaking of some of the details," says Ross.

When NASA finally has a suit for all sizes, each astronaut will be able to accessorize with his or her own wardrobe of gloves, the toughest engineering problem in the higher-pressure suit. A separate design competition, this one between ILC Dover and the David Clark Company, makers of early NASA pressure suits and manufacturers of protective equipment and communications gear, is being run in search of a glove that fits like one. "We've all had hand troubles," astronaut Gerald Carr says.

"As envisioned now, each EVA crew member will probably carry up to as many as three pairs of gloves for his 90-day stint," says Johnson's Joe Kosmo. "Maybe one design that's better for manipulative tasks, another for gross handling of large trusses or payload packages."

Here, as with the suits themselves, test results for the competing sets of gloves aren't yet available. But at least one astronaut, Sonny Carter, has reported a pleasant surprise from his customized ILC glove. At the end of a long task board session underwater he not only tied knots in cord the size of a shoelace, but also threaded a bolt on the end of a no. 6 screw, demonstrating the glove's dexterity on a screw shaft no wider than this capital "O."

A new concept is at work in the design of both suits and gloves. Initially protective, then flexible, they now must be durable. The direction is clear: astronauts are going to space to stay.


THE STRANGE
CASE
OF

What drove this mild-mannered archeologist to become the Hawkman—winged scourge of evil?

by Carl A. Posey *Illustrations by Tibor G. Toth*

CARTER HALL

They were hard and evil times; they were airworthy ones as well, although nobody had a very clear sense of it. As the 1940s began, we would flinch at news of Hitler's army or shudder at the pictures of atrocities in Warsaw and Shanghai, but there was little understanding of what all this cruelty portended. We would also look up at the occasional airplane passing by, but with little appreciation of what it was to fly, except that it was remarkable. Somehow, those DC-3s and Sikorsky flying boats and Stratoliners, like the bleak black and white streets in early images of the war, were always filled with somebody else.

A dubious art form—the comic book—was just then gearing up for what would become its golden age, a time when the evil and the airborne were both simplified in the comics' pages. The real thugs in American streets were transformed by the comics into stocky, stupid men with glass jaws, green suits, and tommy guns that somehow hurt almost no one. In this ink world, the Nazi juggernaut could be contained by a few right-minded men with .45s. The Japanese were small, large of tooth, bright yellow in color, and so fanatically engaged in their bad cause as to be manageable, like any bad-tempered people; of course, one could also get in close and use the good old American right hook. Evil—real evil—generally came from the Middle East, in some timeless and immutable guise.

In the world of ink, flight was firmly allied with goodness—flight was the way to take the righteous fight to the enemy, whether he wore a double-breasted pinstripe or a gray SS uniform. You did it either by yourself, using natural or acquired powers, or with the help of a machine. But to be truly super, one would have to fly unaided. Carter Hall—he who became the Hawkman—must have understood all this. He must have seen subtleties that were lost on a lot of ink people.

The process that led Hall to become the winged crime fighter known as the Hawkman may never be completely revealed. This wealthy research scientist and collector of antique weapons was more than just a pretty face in a sweater vest and baggy suit. He was a veritable onion of obsessions, but obsessions kept close—there was never, for example, the slightest surface evidence that he had given a moment's thought to flight. And yet, how could he not have?

When we meet Carter Hall in the pages of *Flash Comics* no. 4 in April 1940, flight is . . . well, like the war, flight is in the air. One knows Hall has spent hours, *years*, before this moment working toward the Icarian dream he will finally fulfill so perfectly. One imagines him with his pipe and smoking jacket in his weapon-lined library, pondering a world full of evil. There was larceny in the streets and war in distant Europe, as well as the evil of antiquity, steaming toward our tranquil hemisphere from the trackless desert. To Carter Hall, as to so many of us then, this last was the only real evil around. The other nightmares still lay in the future.

Compelled to take a stand against the evil rising about him, Hall has to decide which way to leap. For others in the ink world, the choice has been straightforward. In the days before radioactive mutations and other credible superness-engendering devices came to the comics, you were either super or you weren't. If you were, you knew it from birth, or at least from that crazy afternoon when you bench-pressed a Buick. Or perhaps you caught superness in a lab accident, as you would a virus, or, like hard-fisted detective Jim Corrigan, later the

Spectre, you acquired your powers by (*ugh!*) dying.

Before he became the Hawkman, Carter Hall must have passed many a night in his weapon-lined library, brooding over his possibilities. There was, for example, the case of Superman, who had evolved in just two years from being merely strong—he has the compact, powerful build that comes from being born in Krypton's high-gravity environment—to being nearly indestructible. The powerful leap, which in 1938 was good for 200 yards, max, had become virtual flight, and the day was not far off when Superman, flying superluminously against Earth's rotation, would travel back and forth through time.

To be super, then, forget leaps, even gigantic ones; one must fly. Hall has seen proof of this in the thin, tense line of Batman's mouth when he's working with someone truly super. Swinging on a silken cord may get you across Gotham City quickly, but no one—Batman least of all—thinks of it as flight. Even the Batplane, when it arrives, will be grossly sub-super.

Like all ink people, Carter Hall knows more or less what's on the horizon. He hears the chit-chat of cartoonists, and there is all that back-and-forth among characters when the place is locked up for the night. He knows, for example, that an android incongruously named the Human Torch is about to blaze across the skies of New York. Hall may wonder briefly about the method of flight—how does he vector his thrust? why doesn't he end up just sitting on the ground in flames?—but these considerations are academic: the Torch is neither super nor mortal; he is a mere flaming *thing*.

A year beyond the Torch is his opposite and nemesis, a creature from that other primal element: Prince Namor, the Sub-Mariner, a ruler of the sea. Angry about real or imagined mistreatment by America, Namor vows to destroy the North American continent, working from New York. This aquatic athlete is not only gilled and capable of surviving at great depths, he also has small, Hermes-like winglets sprouting from each ankle. In an epic struggle between fire and water, the Human Torch and Sub-Mariner will fight to a memorable final frame, in which the Torch singes away Namor's winglets with a well-thrown fireball. Eventually the little wings grow back—but by then Namor and the Torch will be pals.

Who else is there in the ink world? There is someone called Wonder Woman, still an unknown quantity but said to be very powerful indeed—and also flightless, unless one counts an "invisible" airplane, with the Amazon aviatrix seated visibly within, at primitive controls.

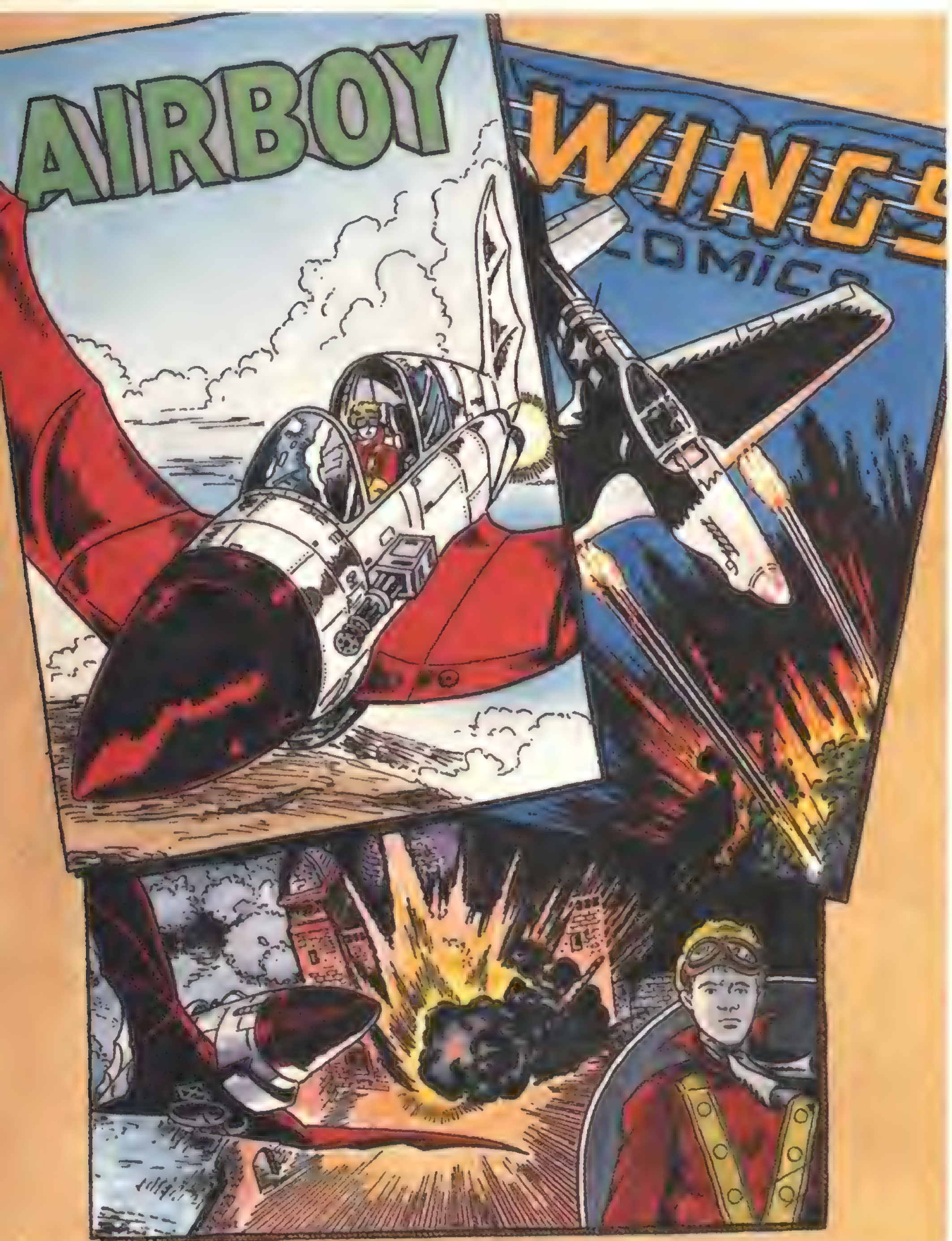
And there is one other, now only a year away. Captain Marvel, the super-alter-ego of young Billy Batson, boy broadcaster, evokes Fred MacMurray and shares so many attributes of Superman that he will finally be erased by superlitigation. But in the meantime he flies in a straightforward fashion—no vestigial jumping position here, or that odd battering-ram posture later adopted by the plaintiff.

Given the difficulty of becoming super, Hall must have weighed the idea of carrying the fight to evil on mechanical wings. *Who knows?* he may have mused, *there could be just enough evil in this Axis thing to be worth fighting.* Some of the young chaps in his part of Inkville are already out there, flying against the Hun in what can only be called generic airplanes. These are mutations of Ryan trainers and BT-13s, Coronado flying boats with six engines, or skis, and airplanes

that look a cross between Stukas and P-40s, the only aircraft anyone in the comic book industry could draw. There is also a sleek retractable that evokes a P-51 without its underslung airscoop. This is a kind of missing-link airplane, the precursor of the real machines that would begin to appear in the comic books after about 1943, when airplanes made the transformation from distant silhouettes against the sky to a visible, *actual* element in American life.

Captain Wings, the major attraction of *Wings Comics,* flies a radial-engine generic, then graduates to a quasi P-51 painted with eagle feathers. In time Wings will fly an eagle-painted P-51 as nicely executed as anything in the dailies—the generics are just what the artists used as a bridge from a time when airplanes were rare to a time when they filled the skies. Generic crashes, however, will remain a preferred method of moving our hero into face-to-face contact with his adversaries,

THERE ARE TWO OTHER ROLES CARTER HALL COULD CHOOSE! ONE HAS REAL AIRPLANES: THE OTHER, REAL EVIL!



usually a skillful stall into a "pancake" landing. The real dynamics of aircraft crashes are yet to be revealed, and then mostly in books without pictures.

There are two possible roles suitable for Carter Hall. One has, eventually, real airplanes—well, almost real—and a cast that makes you want to be an actor. The other has the only machine Carter Hall could ever love, plus . . . real evil.

The first, Hall hears on the Inkvine, is a man calling himself Blackhawk. Within a year, Hall knows, Blackhawk and his six good men will be operating from Blackhawk Island, somewhere in the Atlantic, flying Grumman Skyrockets and wearing what look like blue-black Polish uniforms (see "Hawkaa-a-a-a!," opposite page). Carter Hall can visualize himself yelling "*Hawkaa-a-a-a*!" into a mike and peeling off to fight the enemy. Being Blackhawk could do it for the Hawkman.

The other is just a baby to Hall. Davy Nelson, the lad who will become Airboy, holds little interest for our brooding, latent superman. No, Carter Hall's interest lies entirely with Airboy's winged machine, the lovely ornithopter called Birdie. She—and Birdie will *always* be a she—has a jet-sleek body, a vertical stabilizer indented like the trailing edge of a batwing, and bat-like wings that flap. She is fast but can hover; she responds to her pilot's spoken commands. And she is dangerous—a liquid-cooled Maxim is mounted on either side of her open cockpit, within easy reach of her master's gloved hands.

This is more than enough for Carter Hall. But there is something still more compelling: Airboy will now and then turn away from the predictable political evil of the Axis to take on evil so deep, so ancient and endemic, as to take the form, for example, of zillions of conquesting *rats.* If that isn't real evil, what is? Carter Hall might have followed the path taken by Airboy and the ornithopter except for one unavoidable fact: it would have meant the end of his quest for true superness.

It is at this point that we first actually encounter Hall in that April *Flash Comics.* "In the weapon-lined library of Carter Hall, wealthy collector of weapons and research scientist," we meet this young man, tall, blond, dressed like all research scientists of the period. A package has just arrived from Egypt—probably another weapon. He rips it open to find a glass knife, the type used to offer ancient sacrifices. The knife begins to glow, and, "as though hypnotized by the knife, Carter lunges to the floor! And sleeping—a strange, weird dream unfolds!"

In his dream, Hall is Prince Khufu of the Old Kingdom dynasty, struggling with the false priest Hath-Set. Khufu/Hall loves a pretty brunette named Shiera (later, Hawkgirl), stunning in cape and brass briefs. Hath-Set, aided by the angry god Anubis (here the hawk god, but as everyone with a weapon-lined library must know, in truth the jackal-headed god of the dead), ceremonially slays Khufu with the glass knife. As his life slips away, Khufu utters a last prophecy: "I die—but I shall live again—as shall you, Hath-Set."

Hall awakens from this vivid dream with the equanimity of the rich, puts the knife away, and wanders out into New York. There he finds the subway rails are being overcharged with electricity, frying passengers. He also bumps into the reincarnation of Shiera. He takes her away from the glowing rails, tells her his story, and leaves her for his laboratory. There, he "tunes in his dynamo-detector" to find the source of the de-

Hawkaa-a-a-a!

At about the time Carter Hall takes the oath as Hawkman, another hawk gains his identity in the skies over Poland. There, the generic German fighters of Captain Von Tepp's infamous "Butcher Squadron" are systematically gunning down what appears to be Poland's last squadron of Polikarpov I-16 Moscas. Only one of the Polish aviators escapes, a masterful pilot who is shot down only after taking more than his share of Butchers with him. He crashes in one of those common, generally harmless "pancake" landings and swears vengeance against tyranny.

Not long afterward, news trickles back to occupied Europe that someone calling himself Blackhawk has begun flying and fighting out of a remote island somewhere in the Atlantic. Inevitably, Von Tepp and Blackhawk, who is that same canny Polish aviator (later he will be revised into an American ace who was only helping out in Poland) have a return engagement, dueling in generic airplanes over Blackhawk Island. Because the Nazi sabotages Blackhawk's fuel system, the fight nearly ends in a tie, but Blackhawk manages to crash next to Von Tepp's wreck, where he finishes the job on the ground, *mano a mano.*

Soon Blackhawk is joined by six other refugees from tyranny—Andre, the slick Frenchman; Stanislaus, the stolid Pole; Hendrickson, who turns out to be an impossible combination: German *and* good guy; Olaf, the big Swede (though more likely a Norwegian), almost as stolid as Stanislaus; Chuck, the American (much later we learn he is the former Grumman employee who helped the Blackhawks avoid generic aviation); and Chop Chop, a grotesque caricature from China who at first cooks, cleans, and launders, although eventually he earns his wings. It isn't Henry James, but it is a lot of characterization for Ink City.

Blackhawk was clever about what to fly. While everybody else, including Captain Wings, thundered around in generic airplanes, Blackhawk quickly chose the least generic design of the period. In June 1938, the U.S. Navy asked Grumman to build Design 34, a twin-engine, folding-wing monoplane that could fly from aircraft carriers. At the time, the fleet fighters were still mostly biplanes, and carrier-based single-engine monoplanes were only in the trial stage. The result, the Grumman XF5F, flew for the first time on April 1, 1940, about the time the man who would be Blackhawk was fighting Von Tepp.

The new airplane—journalists dubbed it the Skyrocket—looked like nothing seen before or since. The fuselage started just aft of the wing's leading edge and ended in twin vertical tails. Two 1,200-horsepower Wright R-1820-40 Cyclone nine-cylinder engines jutted forward from the uninterrupted wing, and four machine guns—two .50s and two .30s—protruded from the rounded nose. The cockpit, in these days before the plastic bubble, was a raised greenhouse. The Skyrocket grossed nearly 10,000 pounds, climbed at 4,000 feet per minute, and had a maximum speed of 383 mph, a 210-mph cruise, and a service ceiling of 33,000 feet. It could carry 40 light anti-aircraft bombs in the outer underpanels of its wing. It had the performance Blackhawk needed and, with its twin engines, twin tails, and improbable fuselage configuration, it would be pure hell to draw in perspective.

The Skyrocket pushed generic airplanes out of this strip very early in the game. A few months into the series we see the first model, with the right fuselage and tail, but . . . hold it, two big generic in-line engines? This was swiftly replaced by the real thing, a bit more heavily armed, perhaps, sometimes sporting a four-bladed prop, sometimes not. Eventually there are seven operational Skyrockets (as well as an indeterminate number waiting off-stage, to step in as the others pancake-land all over occupied Europe), peeling off to the sound of the Blackhawk battle cry: *Hawkaa-a-a-a!*

The mystery, of course, is where all the Skyrockets came from. The single XF5F built by Grumman accumulated 155.7 hours in 211 flights but ended sadly—after a wheels-up landing at Naval Air Station New York in 1944, the airplane was written off and handed over to the fire crews for training. But the type lived on, spectacularly, with the Blackhawk squadron until well after the war had been won.

What Carter Hall Could Not Have Known

Across the tracks, in the swank Ink City neighborhood of the dailies, ink people were already flying recognizable, not generic, aircraft.

Smilin' Jack, mainly a pilot of light aircraft, had been airborne since the early 1930s, no doubt one of the very few people left in America then who could afford an airplane. In 1940 he drifted toward wartime service with the Civil Air Patrol and had some brushes with real evil, mostly in Latin America. There was nobody worse than The Head, for example, a twisted twin of Peter Lorre with a piranha pool that could transform a horse—or a pilot—into a pile of bones in a couple of panels.

The Orient was both mysterious and red hot, war-wise. Scorchy Smith had been over there for years, flying what looked like a Brewster Buffalo on behalf of what seemed to be Chinese. Terry Lee's pirates were increasingly an ochre swarm of soldiers called "the invader," later to be known as the Japanese army. While not quite airworthy—Terry was still two years from his flight officer's bar and pilot's wings—the young American had spent his adolescence among people who flew.

Barney Baxter, who just three years earlier had rescued the throne of tiny Brazona, was already fighting over Europe. Before 1940 ended, he and his degenerate sidekick, Gopher Gus, signed up with the Royal Air Force. The machines Baxter flew were splendid. They looked real, yet there was something unreal about them too—they had an aura of illusion, heightened by the delicate hatchwork on the undersides of the wings and horizontal stabilizers. And they were singular designs, delicate craft with short bodies and pusher props and slender booms going back to a twin tail, and fighters with contra-rotating propellers. They had the distinctive, odd look of early Saabs.

A few years down the road there would be others, none better than Buz Sawyer and his gunner, Sweeney, landing SBDs and Avengers aboard the carrier *Tippecanoe.*

But Carter Hall could not have known any of this. Weapon-lined library or not, his world was the ghetto of the comic books. The posh universe of the daily strips was light-years away from our wealthy research scientist and the decision he would make that fateful spring.

structive voltage and "emerges shortly after from his weapon room clad, as a grim jest, in the guise of the ancient hawk-god, Anubis . . . . The Hawkman—Peril of the Night—whose extraordinary powers are derived from Carter Hall's discovery of the secret of the ages—the ninth metal—which defies the pull of the Earth's gravity—and The Hawkman goes forth!" And as he goes forth, Hall says to himself, *"I must have known this night would come . . . "* Considering the preparations required, this is super understatement indeed!

First of all, Carter Hall has undoubtedly been brooding endlessly about the road to superness. Furthermore, perhaps inspired by the example of Superman's ever-increasing leaps, he has been laboring to find a gravity-repelling material. The object of his quest turns out to be the ninth metal, a nonconductor that "repels electricity, which is the base of the force of gravity!" This was not the search of an afternoon. Nor is the costume in which he emerges something you'd just toss together. He wears enormous wings that will evolve into huge ear-shaped structures that seem to be made of purple hair. His chest, which, as a show of confidence perhaps, is as bare as Clark Gable's, is crossed with a light harness for the wings. His belt is made of the ninth metal, which provides lift. The wings, one presumes, solve the propulsion problem, although how they are made to flap is a secret Carter Hall will carry to the grave. He wears green tights and red jockey shorts over them—leaving the reader to ponder the effort involved in tracking down red jockey shorts in New York in 1940—and sheer superhero boots. As a final touch, he hides his identity behind a bizarre hawk mask that may be out of ancient Egypt but is so outsized and stylized as to be prized among the Kwakiutl Indians of the Pacific Northwest. Finally, he adds a few rocks, a sling, wooden staff—old stuff from the weapon room—and . . . goes forth.

It should be obvious what Hall has done. He has drawn from each aeronautical possibility. He has acquired flight, the key ingredient of superness, by becoming himself the ornithopter, the machine. He has inoculated himself with fantasies of death and reincarnation in order to lift himself out of the common wealthy-research-scientist mold and head off on the road to being extraordinary. He is not Blackhawk; he is the Hawkman. His enemies will be strong criminal minds of large purpose, driven by that deep evil from the bottomless well of old Egypt.

Now it is just a matter of maturing in the role. For, like all supermen and -women, like all ink people, Carter Hall is an actor as well as a scourge of evildoers. He will play the role of the man who flies like the hawk with courage and élan. As his character evolves, he will become quintessentially avian, a man who not only flies but can communicate with all flying creatures—he becomes to birds as Tarzan became to apes.

Ah, what a role, and how he will play it. How he will fly!

essay

Nuclear Power in Space: Balancing the Risks and Benefits

George E. Brown Jr.
U.S. Representative
(D-Calif.)

I strongly oppose the deployment of weapons in space.

Space nuclear power has enabled us to go where no man has gone before. Early astronomers, such as Galileo, Copernicus, and Ptolemy, could not have dreamed of the incredible images of Neptune recently sent back from Voyager 2. The Voyager probes—as well as the Viking landers and Pioneers 10 and 11—stand out as some of the best scientific accomplishments of this century. None would have been possible without radioisotope thermoelectric generators (RTGs). The same is true of the Apollo effort. Without the use of RTGs as power sources, the scientific experiments conducted on the moon would not have been possible.

Expanding on our knowledge in such ways is the lure of space and the essence of science. But in spite of the tremendous benefits we have reaped from space nuclear power, I have serious reservations about it—specifically, its use in Earth orbit. The prospect of an accident involving a nuclear-powered satellite reentering Earth's atmosphere has led me, with a host of my colleagues, to introduce legislation to ban the use of nuclear reactors in orbit around our planet.

History has demonstrated how difficult it is to launch and maintain nuclear-powered satellites. In the past 30 years, the United States and the Soviet Union have launched more than 60 spacecraft with nuclear power sources on board. Approximately 15 percent of these missions have suffered some form of failure or accident, some of which have resulted in significant releases of radioactivity into the environment. The most serious incident occurred in 1978, when a Soviet spacecraft reentered Earth's atmosphere and spread radioactive debris across nearly 40,000 square miles of northwest Canada.

The Soviet Union is currently the only nation still launching nuclear reactors into Earth orbit. The Soviets have orbited more than 30 nuclear satellites in the past two decades and they now employ radar ocean reconnaissance satellites (RORSATs) to track U.S. naval vessels. This fact leads many U.S. military officials to argue that the United States needs to launch a multi-billion-dollar anti-satellite (ASAT) weapons program as a countermeasure.

At present, neither the United States nor the Soviet Union has a reliable means of disabling military satellites. That is as it should be. It makes sense to negotiate an ASAT Limitation Treaty to preserve this situation. But instead, the Pentagon has announced the initiation of a new ASAT program, which it argues is critical in order to shoot down RORSATs. Efforts by the United States to put weapons into space will surely provoke the Soviets into undertaking similar efforts. Each U.S. deployment would invite a Soviet response; each Soviet response would prompt a U.S. counter. This measure-for-measure competition would bring a host of dangers. Space would become a hostile arena.

I strongly oppose the deployment of weapons in space. At a time when the world is faced with unprecedented human suffering and the prospect of global environmental crises, when our nation is overwhelmed with the crime and corruption caused by illegal drugs, and when we have accumulated enough debt to bankrupt the nation's economy for generations to come, I can think of no greater folly than a dangerous and costly U.S.-Soviet competition in space weaponry.

In the event of a U.S.-Soviet ASAT arms race, I am convinced that U.S. national security would suffer. We are far more dependent upon military satellites—for communications, early warning, navigation, and intelligence gathering—than the Soviet

It's time to make Earth orbit a nuclear-free zone.

Union. This is in part due to geography, since likely points of U.S.-Soviet conflict are on the Soviet Union's periphery, and in part due to technology, since we have done a better job of exploiting the military opportunities afforded by satellites.

Instead of developing the capability to shoot down RORSATs, a better way to reduce them would be persuading the Soviets to abandon the program. My proposed ban on nuclear power in Earth orbit is designed with that goal in mind. The central provision of the bill, which would go into effect only if the Soviet Union took the first step by ending its RORSAT program, is aimed at establishing a U.S.-Soviet moratorium on the use of nuclear power in Earth orbit.

Specifically, the bill calls on the president of the United States to urge the Soviet Union to end the use of nuclear-powered satellites. The United States would then be prohibited from launching spacecraft into orbit with nuclear power sources on board. Compliance with the ban could be easily verified due to the strong gamma and infrared signals emitted by space reactors. Also, Earth-based sensors can easily detect the distinctive design of the reactors, which include radiator panels and a shielding system to protect onboard electronic systems. If the Soviets were found to be in violation of the agreement, the United States would then be released from its restrictions.

Considering the Soviet government's strong interest in avoiding an arms race in space, now would seem to be a good time for the United States to propose a ban of this sort. Soviet scientists, including Roald Sagdeev, an advisor to President Gorbachev, have endorsed such a ban. My legislation would help determine whether the Soviets are really serious about abandoning RORSATs.

There are some who worry that adoption of my bill would have an adverse effect on U.S. plans for space. According to the American Physical Society's 1987 report on directed-energy weapons, the Strategic Defense Initiative program could require "perhaps a hundred or more" nuclear reactors in space. A single SP-100 reactor—the type being developed primarily for the SDI program—could have several hundred times the amount of long-lived radioisotopes as does a single RORSAT. A space-based defense could increase by tens of thousands to hundreds of thousands the amount of radioactive, bomb-grade uranium circling the globe. Add to this a Soviet space-based defense also fueled with nuclear reactors, and I shudder to think of the consequences of an accident.

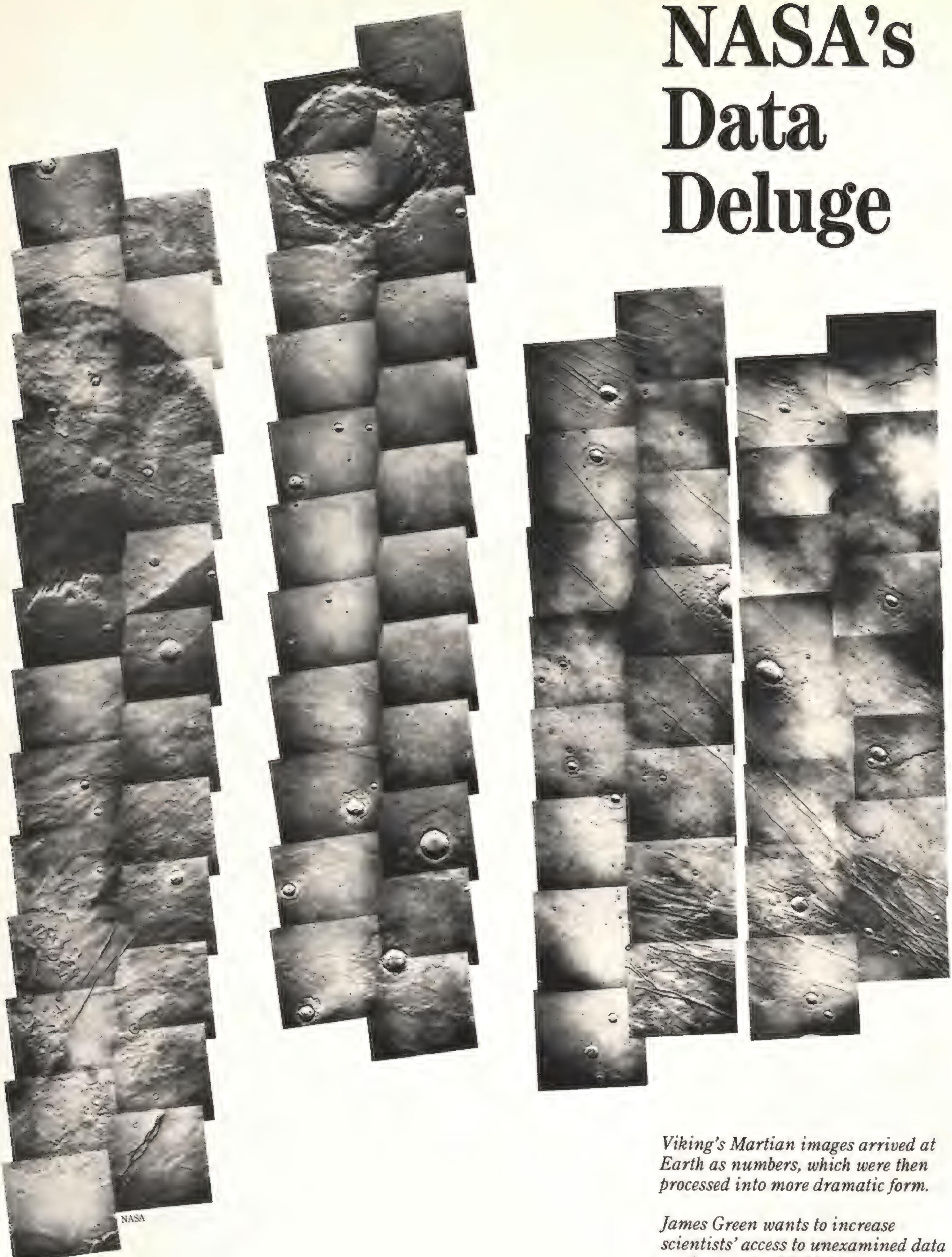
The bill would have no harmful impact on the civilian space program.

This bill is not an attempt to kill the SP-100 program. I support its continued development. However, its development schedule should be paced to meet specific civilian applications, such as developing a power source for a lunar base, and not propelled by an unwarranted enthusiasm to build a space-based defense.

It is also important to emphasize that there would be no harmful impact to the nation's civilian space program if my bill were adopted. The final section of the legislation states that nothing in the bill shall prohibit the use of nuclear power sources for deep-space scientific and exploration missions or for a moon base.

I want this nation to have the best civilian space program possible—not a network of radioactive satellites or orbiting battle stations circling the planet. Space should be explored for the common good of all, not turned into another stage for nationalistic rivalry. Proposals for the civilian use of space reactors are not worth considering if they can only be developed through a Faustian bargain that includes space weapons.

NASA's Data Deluge


NASA

Viking's Martian images arrived at Earth as numbers, which were then processed into more dramatic form.

James Green wants to increase scientists' access to unexamined data on thousands of NASA tapes.

As spacecraft pour out an ever-increasing flow of data, NASA scrambles to handle the flood.

by Richard Wolkomir

Some space scientists call it the black hole. Others refer to it as a tape landfill. By any name, the archives where NASA stores its space data is an embarrassment of riches. Over the past 25 years of space exploration NASA has accumulated some 125,000 data tapes, most of them stored inside a government warehouse outside Washington, D.C. "Less than 10 percent of that data has ever been looked at," says William J. Campbell, a computer scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

An even greater information glut looms on the horizon. The Cosmic Background Explorer, the Galileo mission to Jupiter, the Hubble Space Telescope, the Gamma Ray Observer, the Ulysses mission to the sun's poles, the Mars Observer, and the TOPEX/Poseidon ocean sensing satellite are all scheduled for deployment within the next three years.

LEE BATTAGLIA

Scientists say the task of analyzing all that data will be comparable to drinking from a fire hose.

Committees of space scientists have been debating how to handle the coming deluge. Part of the problem is technological: the sophistication of spaceborne instruments has outpaced the development of software to analyze the data the instruments spew out. Managing and storing the data once it has been analyzed is another headache.

But the biggest issue is funding. "NASA's policy is to put instruments up there and support research with them for a year, and then go on to something else," says Brigham Young University geologist Eric H. Christiansen. "But that's not enough time because analyzing data is a lengthy process—there's got to be an equal sum of money invested in the analysis of the data."

Where will that money come from? Roy A. Maxion, a Carnegie-Mellon University computer scientist, wonders about the sacrifices. "If you build up data analysis," he asks, "will you have to cut space exploration?"

Data from space instruments arrives at Earth in the form of binary numbers—"1" and "0." Each digit is a "bit"—combined into a unit of eight they become a "byte," much as letters make up words. A layman may see the long streams of digits as mathematical gibberish, but even a scientist requires the services of a translator.

Take, for example, the data that will be gathered by the Magellan probe, now coasting toward Venus. When it begins to orbit the planet in 1990, Magellan will beam radar waves at the surface and record the returning echoes as bits.

The probe will transmit the bits to the antennas of the Deep Space Network, which will send the information to computers at NASA's Jet Propulsion Laboratory in Pasadena, California. There it will become the responsibility of the project team, made up of everyone directly involved in the mission, from the designers of Magellan's radar scanner to planetary scientists who will comb the data for information about the planet's evolution.

When the data arrives at JPL, it is in unprocessed, "level zero" form that will be inaccessible to scientists. The project team will process the bytes into level-one data by translating the binary numbers into standard, base-10 numbers. Magellan's numbers will represent the intensity of the echoes the radar scanner receives as it orbits above a strip of the Venusian surface.

These numbers will need even further processing. The team will convert them to usable level-two data with a mathematical formula that takes into account everything from the spacecraft's orbit and inclination to the radar scanner's idiosyncracies. Then the data (mostly on computer tapes) goes to the the end users—the scientists who actually study it. They will sort out the different reasons for variance among the returned signals. Differences in rock sizes, the angle of the surface's slope, even the electrical properties of the ground will affect the signal.

The users may work for NASA, universities, or other research institutions. Their work, sure to take years, will include further transforming the data into analyzable maps and images. But scientists are short-handed. Graduate students are the GIs in the data trenches, and a long drought in space exploration has dried up the grad student reservoir. NASA is also suffering a brain drain as older scientists retire.

Funding is often a problem. During the Viking mission to Mars, investiga-

tors encountered delays of six to eight months before they received their data because the funds necessary for data processing had been underestimated. "The support goes to rockets and spacecraft, and money for that gets allocated at an accelerating rate," says Eugene H. Levy, director of the University of Arizona's lunar and planetary lab. "Certainly the spacecraft are important, but the investment in doing science just doesn't keep pace."

Take the case of Nimbus 7. Since 1978 the Total Ozone Mapping Spectrometer (TOMS) aboard the satellite had been mapping Earth's ozone layer, the portion of the atmosphere that shields the planet from dangerous ultraviolet radiation. Had researchers been able to watch closely over the raw data, they would have seen a hole growing in the ozone layer over Antarctica, a disturbing gap in Earth's protective shield. "There was very limited funding for analyses of those data back then—my proposals for funding to do those analyses never were accepted," says Arlin Krueger, the NASA atmospheric physicist in charge of TOMS.

By 1985 scientists at a British meteorological station in Antarctica saw signs of the hole in data from their ground-based instruments. "So we started looking at our data for Antarctica then and we *immediately* saw the ozone thinning," says Krueger.

According to Andrea Dupree, a senior astrophysicist at the Harvard-Smithsonian Center for Astrophysics, the funding problem is not a new one. Data analysis was underfunded as long ago as the 1960s, when Dupree was a Harvard graduate student working with the Orbiting Solar Observatories. "They were launched every few years and no sooner did the data come down then you'd have to get on to the next launch," she says.

Among the OSO team's major findings was that the source of the solar wind is "holes" in the corona's magnetic fields, which allow gases from inside the sun to shoot out into space. "But we could have made many further discoveries if we'd had enough funds and people to really work with the data and plan for the next mission based on what we learned from the current mission," Dupree says.

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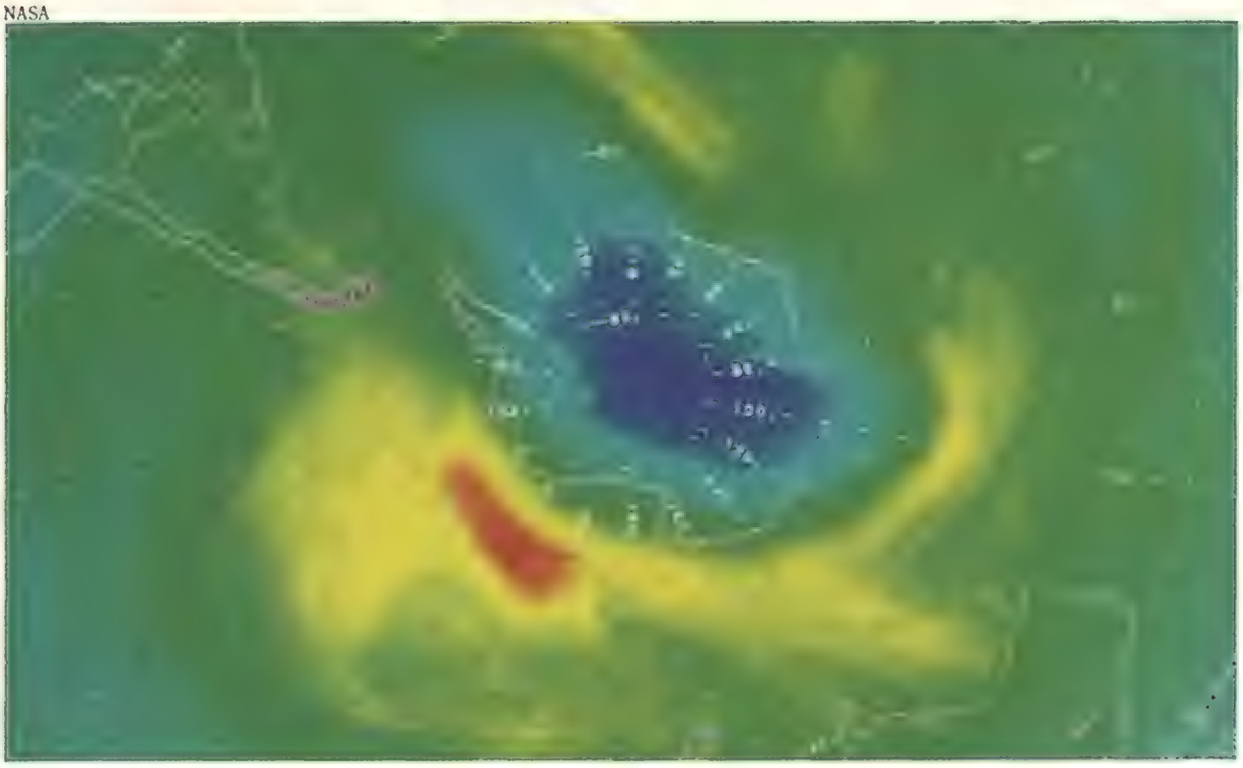

LEE BATTAGLIA

Scientists have a number of ways to manipulate data from TOMS, Nimbus 7's ozone mapper. Software that converts the data into color-coded images (top) makes ozone trends more apparent. Goddard computer scientist Lloyd Treinish (right) is working on a program that represents the ozone layer three-dimensionally (opposite). The Antarctic ozone hole appears as a cavity.

In the years since the OSO missions, space science has become even more complex. Armed only with its radar scanner, Magellan will send back four trillion bits of data, enough to fill 500,000 fat books or two million standard PC disks. That is far more data than was sent back by all previous planetary missions *combined.*

The Earth Observing System, scheduled for deployment in the late 1990s, promises even more of a data headache. EOS will have more than 25 orbiting instruments to scrutinize the entire Earth, including everything from foliage changes to continental drift. "That project, in less than one week, will generate more data than we've accumulated in the entire archive over 20 years, and it will just keep coming in, year after year," says Goddard's Campbell. To prepare for this onslaught, NASA has started the EOS Data and Information System. Scientists involved in EOSDIS are studying what current technology will require to meet the demands of EOS, such as high-speed storage capabilities, better archiving and distribution services, and more efficient methods of extracting meaningful information from the data.

Analyzing complicated sets of data would be impossible without the aid of computers, but buying the machines or even renting time on them is expensive. Furthermore, astrophysicists and planetologists aren't always adept with computers, says Richard Hart, executive secretary of a National Academy of Sciences committee that has studied NASA's data problem. One solution? "Let's create computer programs that make data analysis so simple even astrophysicists can use them," says Hart.

A small contingent of NASA computer scientists is attempting to do just that. Because even a spike on a graph or a splash of red in a visual can instantly reveal an important finding that would be hidden in the numbers, Lloyd Treinish, a computer scientist at Goddard, is developing ways to present complex data sets pictorially. Using software Treinish has developed, a sci-

entist can call up data from Nimbus 7 on his computer screen and see a representation of the ozone layer on any day during the past 10 years. The layer looks like a three-dimensional sphere, with the Antarctic's thinning ozone hole appearing as a cavity. The scientist could pick a particular moment in time and, on the screen, juxtapose atmospheric pressures, temperatures, and the ozone structure in a search for correlations. Or the researcher might switch to a contour map to zoom in on details of the ozone structure over a few miles of Antarctic coast.

A team working on a similar system at JPL has already scored a hit. Computer scientist Sylvie Rueff says her NASA team helped Rice University astrophysicist Gerd-Hannes Voigt discover an anomaly in Uranus' magnetosphere by creating a video of the swirling magnetic forces.

At Goddard, William Campbell is developing an artificial intelligence system that would help a researcher finetune his requests for data before he begins wading through the numbers—"putting the smarts up front," as he puts it. "The user walks up to his terminal and talks to it in plain English, telling it what he wants to do," says Campbell. The program "thinks" like a geologist, astrophysicist, or whatever the researcher's specialty is, and analyzes the best way to answer the scientist's question. As the system interacted with scientists, it would learn from its mistakes. "It would modify itself, getting smarter and smarter," says Campbell.

Once a mission's principal investigators have finished with their data, they are supposed to return it to NASA's archives so that other scientists can have a crack at it. NASA's head archivist is James Green, the director of the National Space Science Data Center at Goddard, established by NASA in 1966 to aid scientists who wish to do research beyond that done by the mission's principal investigators.

A magnetospheric physicist, Green is striving to make the data center's hoard—already containing about twice the amount of information stored in the Library of Congress' 19 million books—more accessible to his fellow scientists. The center is experimenting with new

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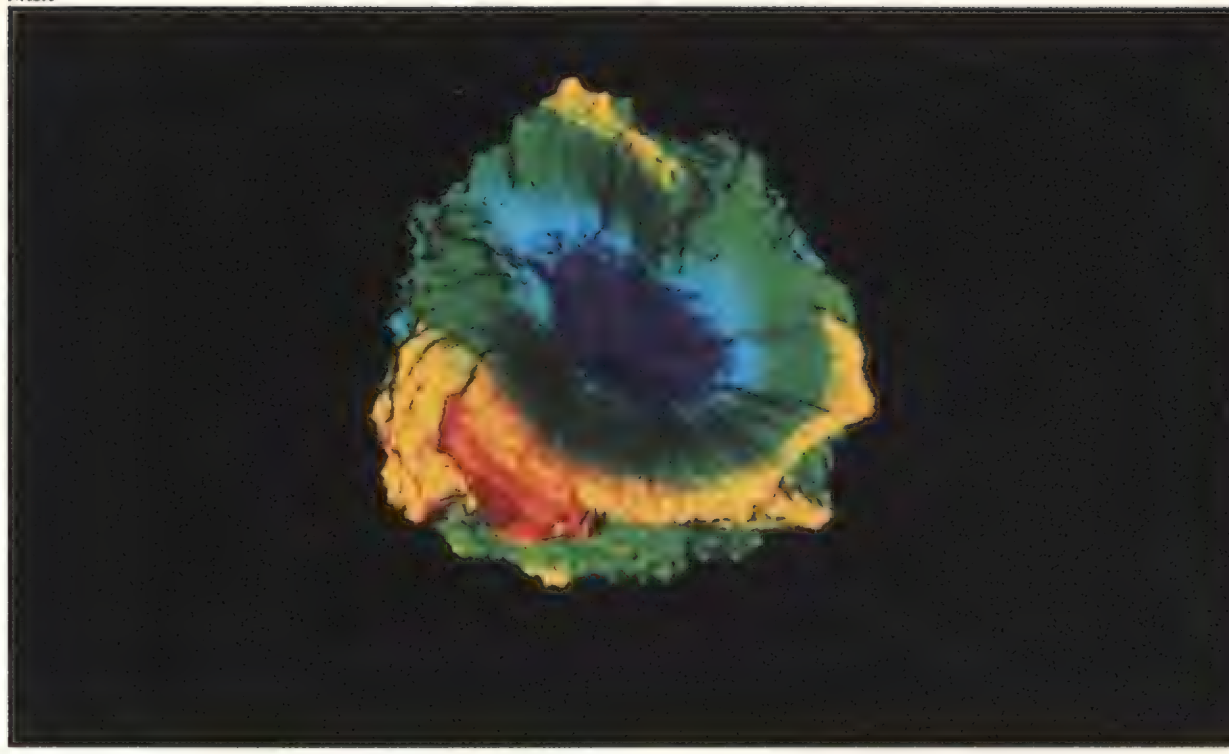


optical disks, "read" by lasers, which hold about a thousand times more data than standard PC disks. They also enable scientists to select data anywhere on the disk, instead of having to unreel a magnetic tape from the beginning to reach a desired spot.

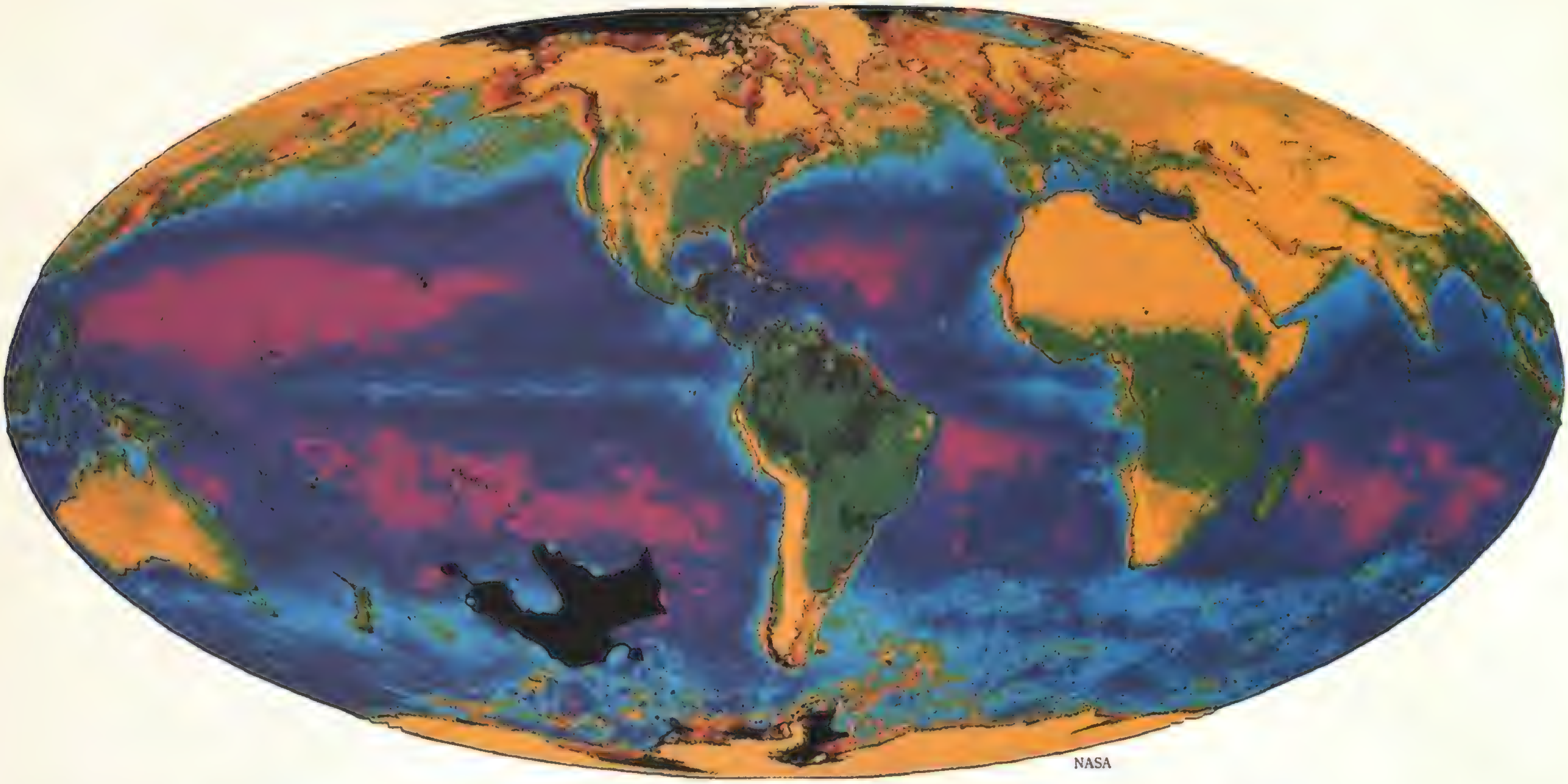
Last year the data center put all data from the International Ultraviolet Explorer satellite on line. Via telephone, scientists worldwide can now summon up the data, already processed, on their own computer screens. Use of the ultraviolet data jumped fourfold in 1988, simply because scientists could get at it. "We got an order from one organization that already had the data, but it would have taken them eight months to get the data off their tape," says Green. Unfortunately, cost has restricted his staff from putting more than a tiny percentage of the archives' data on line.

NASA has also been creating a number of data systems—subsets of the main archive—that are essentially information storehouses for specific disciplines. For instance, JPL runs the Planetary Data System, which contains data from the Voyager and Pioneer missions, among others. The NSSDC runs and operates the NASA Climate Data System, and JPL has the NASA Ocean Data System. Rather than rummaging through the entire archive, researchers looking for information in any of these specific areas can turn to the appropriate data system.

Data tapes are valuable even long after a mission has ended. Researchers continue to ask the data center for Nimbus 7 data. "Volcanologists use the data because the same instrument that measures atmospheric ozone also detects sulfur dioxide, which is emitted in eruptions," Krueger says. Meteorologists and climatologists use the data to trace weather systems. Biologists are using it to calculate ultraviolet dosages reaching plants and animals living under the transient ozone holes that constantly form worldwide. Even ophthalmologists have used the data: a weekend rash of solar retinitis (sunburned eyeballs) in Michigan and New York state recently prompted physicians to call the data center. "We pulled the data, and we spotted an ozone minimum drifting across Michigan and then on to New York state," says Krueger.

Other discoveries have been made in the archives. Cornell researchers Peter Thomas and Peter Gierasch decided to see if Martian whirlwinds—dust devils—help shape Mars' terrain. After scanning thousands of images from Viking spacecraft, they found 99 dust devils. By estimating that a typical whirlwind is over a mile high and can carry three tons of dust, they converted old data into new proof that dust devils have a major impact on the Martian surface.

Astrophysicists, too, find gold in the old data. An example is stellar object H1504 + 65, identified as the sky's seventh brightest X-ray source during the HEAO-1 (High Energy Astrophysical Observatory) survey conducted in the mid-1970s. John Nousek of Pennsylva-



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nia State then discovered that the X-ray source was a faint blue star. He teamed up with University of Delaware astrophysicist Harry Shipman to learn more, using new data as well as material retrieved from old missions—HEAO-1, EXOSAT, Voyager, and the International Ultraviolet Explorer, plus three ground-based telescopes. They announced their findings in 1986. "We discovered it's one of the hottest stars in the universe," says Shipman. "We also discovered it's chemically peculiar, because it seems to have neither helium nor hydrogen."

Older tapes, unfortunately, also act as a barrier to further discoveries. While these tapes have seven tracks, holding 200 to 800 bits per inch, modern magnetic tapes have nine tracks and hold 6,250 bits per inch. Using the older tapes with new-format equipment would be like trying to play an eight-track tape in a compact disc player, and often the hardware needed to read the older tapes is no longer available. In addition, the magnetism on computer tapes has begun to fade over the past decade, resulting in the degradation of data.

So the data center has begun a salvage operation. Some data from the old tapes is being transferred to modern high-density tapes. In the first year of the salvage operation, some 7,000 tapes have been finished. Robert McGuire, who heads the project, knows of no large patches of data lost due to age, but some tapes were so far gone that extracting the data required several rereadings, with lost sections dubbed in from backup tapes. To save 200 valuable tapes from Nimbus 4, workers had to virtually hand-clean the 2,400-foot tapes.

LEE BATTAGLIA

Almost 400 billion bytes of data collected over two and a half years went into this composite image of the global biosphere. Even that wasn't quite enough: the black portions are areas for which information was unavailable.

At Goddard, Green is trying new ways to store and access data, including optical disks and online services.

Scientists will have to continue struggling with the data management problem in the coming years. They themselves may even be partially responsible for it. "Because computers are faster, it's easy to generate huge quantities of data," says Joseph Veverka of Cornell University, "and that's easier than thinking about how to focus your experiment on the key data you need." Veverka worries about one possible future for space science: "On the horizon are these vast empires of people who just manage data."

Roy Maxion of Carnegie-Mellon believes that data management will continue to take a back seat to the more glamorous tasks involved in launching spacecraft. "Long term, though," he says, "it may be Mr. Data Analysis who provides the major new discovery, not Mr. Going To Jupiter."

The Burnelli Controversy

It's been 25 years since Vincent Burnelli died, but the debate continues. His supporters claim that powerful forces have been suppressing his designs. His detractors say that's nonsense.

by David Noland

Below: Burnelli (front) designed conventional aircraft like the 1916 Continental Pusher before turning to lifting-fuselage airplanes with the RB-1 (above).

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"This is the biggest story in aviation history," says Chalmers H. "Slick" Goodlin. He puffs on his pipe and leans back in a 16th century oak chair in the living room of his sumptuous Coral Gables home. A suit of medieval armor sits astride a life-size wooden horse over behind the couch, and banyan trees are visible outside the window. Goodlin, a 66-year-old dealer in used jet airliners and a former test pilot from the glory days at Muroc, is talking about a subject that has consumed him—some would say obsessed him—for nearly four decades: the Burnelli lifting fuselage. This 69-year-old concept of aircraft design is one that Goodlin insists would revolutionize aviation today. "The government and the military-industrial complex have engaged in a diabolical conspiracy to kill the Burnelli concept," he says. "The cost of that conspiracy has been hundreds of billions of dollars and thousands of human lives. It's one of mankind's greatest tragedies of the 20th century."

One day in 1920, a clever young aircraft designer from Texas named Vincent J. Burnelli had a brainstorm. Seeking to increase lift for a larger version of the Lawson Airliner he'd designed the year before, Burnelli hit upon the idea of shaping the fuselage like an airfoil. Instead of simply dragging through the air and unnecessarily burdening the wings, reasoned Burnelli, his fuselage would generate its fair share of lift. Moreover, the lifting fuselage would reduce structural loads on the wing and provide the additional bonus of a cavernous cabin.

Burnelli's first lifting-fuselage aircraft was the 32-passenger RB-1 biplane, which made its maiden flight in 1921. It had a broad slab of a body, curved like an airfoil across the top and bottom and tapering to a knife edge at the rear. The fuselage contributed more than 500 square feet of lifting surface, about a third of the total wing area, and was so wide that the two 550-horsepower Galloway Atlantic engines fit side by side in the nose. An improved version, the RB-2, could carry three tons of freight, an astonishing load in those days, and in 1925 the prototype hauled around a Hudson Essex automobile on an aerial sales tour. But the RB-2 was sluggish and slow, and Burnelli couldn't get financing for production.

He continued to design and build airplanes based on his lifting-fuselage concept into the late 1940s, persuading various backers to fund six more prototype aircraft. None ever went into production, even though Burnelli had the support of big names like Hap Arnold, Clyde Pangborn, and Billy Mitchell. His unusual designs also caught the fancy of aviation buffs of the day, among them an airplane-crazy Pennsylvania boy named Chalmers Goodlin, who built a model of a Burnelli when he was 10 years old.

But the big contract remained elusive. Until his death in 1964 Burnelli continued to sketch designs for aircraft ranging from commercial jet transports to suborbital space planes, all employing his lifting-fuselage concept. The last Burnelli aircraft to fly was the CBY-3 Loadmaster, a squat, bulky twin-engine cargo transport that first took wing in 1947. The only surviving Burnelli, it now sits, forlorn and partially disassembled, in the grass out behind the New England Air Museum in Windsor Locks, Connecticut.

When Slick Goodlin met Vincent Burnelli in 1949, Goodlin too was feeling the sting of rejection by the aviation establishment. Two years earlier, Goodlin, then a dashing 24-year-old test

pilot for Bell Aircraft, had made the first powered flights of the Bell X-1, the bright orange rocket plane that would later break the sound barrier and make a national hero out of Air Force pilot Chuck Yeager. Goodlin took the X-1 to the brink of Mach 1, but it was Yeager who stepped in for the epochal supersonic ride.

According to Yeager's autobiography and the book *The Right Stuff,* Goodlin lost his shot as soon as he insisted on a $150,000 bonus to fly the X-1 past the sound barrier. When the Air Force balked, Yeager took over for $283 a month, his regular service pay.

"That account is false," says Goodlin vehemently, the bitterness still evident. "I had a handshake deal with Bob Stanley of Bell that I would make the first supersonic flight before we turned the plane over to the Air Force. He agreed I'd get $150,000 for the supersonic flights. But the Air Force wanted a man in uniform to break the sound barrier—better PR. And to make Yeager look like a hero, they made up the story about me refusing to fly."

In 1949, Goodlin, who had left Bell to start a used-airliner business, was introduced to Burnelli by a mutual friend. The two hit it off immediately. Empathizing with Burnelli's role as the frus-

COURTESY CHALMERS H. GOODLIN

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Burnelli's designs gained support from several aviation notables, including Clyde Pangborn (above). Chalmers "Slick" Goodlin became a supporter following his pioneering test flights in the Bell X-1 (opposite, top).

The UB-14 crashed because its ailerons were connected incorrectly. Its crew survived—evidence, say Burnelli proponents, that lifting-fuselage airplanes are safer than those flying today.

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trated outsider, Goodlin grew interested in the lifting-fuselage concept, test-flew the CBY-3, and got hooked. "It was the best-flying airplane of the 70 different types I've flown," he rhapsodizes. "It stalled beautifully. You could cut an engine, pull the stick back in your lap, and it would shudder a little and recover by itself. Try that in a C-46 and you're in big trouble."

Goodlin became a stockholder in the Burnelli Company in 1950 and president in 1960. "That about finished me as far as the establishment was concerned," he says with resignation. For, as Goodlin sees it, it has been the aviation establishment that has worked to suppress Burnelli's accomplishments.

Burnelli was dogged by bad luck. One prototype crashed when the ground crew forgot to put in the aileron hinge bolts; another crashed when the aile-

rons were hooked up incorrectly to their controls. A major backer went broke and a government loan was called in at just the wrong time. Sales prospects for the postwar CBY-3 plummeted when the market was flooded with surplus DC-3s at $5,000 apiece.

Burnelli was clearly a talented designer, but he sometimes undermined his own cause. Zealously guarding his lifting-fuselage concept, he patented every detail and always seemed to be involved in patent fights, making him appear a secretive, paranoid outsider to some. Around 1930 the U.S. government tried to buy the rights to Burnelli's patents so that other manufacturers could build Burnelli-style airplanes. Burnelli refused. On the advice of his patent attorney, he also stayed out of the Aviation Manufacturers Association, which had its own cross-licensing and patent-pooling system. At one point Burnelli had a chance to merge with Consolidated, a big establishment manufacturer, but he backed off.

His dealings with the military were also fruitless. Despite repeated rejections, Burnelli constantly bombarded the Army with design proposals that it called "unsubstantiated" and "based on faulty or misleading data." A 1948 Army chronology of its duels with Burnelli runs 30 pages.

Goodlin describes Burnelli as "too nice a man for the cut-throat aviation business." Short, shy, and mild-mannered, Burnelli was far more comfortable at his drafting board than in the offices of Wall Street financiers or Army generals. "Like so many inventors and technical geniuses, he was not a commercial man," says Goodlin. "He was an innocent. He didn't appreciate how dishonest big business could be."

As Goodlin tells it, an event in 1940 perfectly sums up Burnelli's lifelong bad luck and frustration. His A-1 fighter-bomber design, after gaining the support of General Hap Arnold, won an Army Air Corps competition over Boeing, Douglas, and Lockheed designs. An elated Burnelli, the story goes, was invited to the White House to watch President Franklin Roosevelt sign the production contract. While an aide served champagne in the Oval Office, Roosevelt, pen in hand, casually asked Burnelli who his backer was. When told

MARK AVINO/NASM

Burnelli touted his planned B-1000 as an improvement over the American bombers then in service. It never made it beyond the model stage, the victim of "evil political suppression," according to Goodlin.

it was Arthur Pew, the Sun Oil magnate, Roosevelt exploded with anger, threw the pen across the room, and ordered Burnelli out. Pew, it seems, had been a big supporter of Wendell Willkie, Roosevelt's Republican opponent that year. Burnelli never got the contract.

Shortly thereafter, an Army review board issued a report that denigrated the Burnelli lifting-fuselage concept and stated that no Burnelli design proposal "would ever again be considered by the Air Corps." Burnelli continued to submit designs anyway, and finally, in 1948, the Air Force tested the CBY-3 at Wright Field. It concluded that the Burnelli was comparable to the Douglas C-47 in handling and performance, but obsolete compared with newer designs then under development. Burnelli, frustrated after so many years of rejection, never built another airplane.

Since Burnelli's death, Goodlin has carried on the crusade alone—39 years of evangelistic fervor that have brought him little but rejection and scorn. It cost him his first wife. "She told me, 'You love that airplane more than you love me.' I told her, 'You're right, baby.' " He subsequently married his secretary, who, after years of typing acid letters to Burnelli foes, presumably knew what she was getting into.

Goodlin targets Boeing as the kingpin in the anti-Burnelli conspiracy. In 1963 he ran into a Boeing marketing executive in Florida and pitched the Burnelli concept. The executive went home enthusiastic, says Goodlin, and promised to talk to his superiors. But he called back and said Boeing wasn't interested after all. Twelve years later, Goodlin says he got a phone call from the president of Royal Jordanian Airlines. " 'Hey, Slick,' he told me, 'I'm here in Seattle looking at a mockup of a Boeing Burnelli. They're telling me it's the airplane of the future, and they're trying to sell me a fleet of 'em.' "

The mockup turned out to be the model 754 Husky, a freight hauler

The Cunliffe-Owen Clipper, a British-built version of the UB-14, was eventually used during World War II by Charles de Gaulle.

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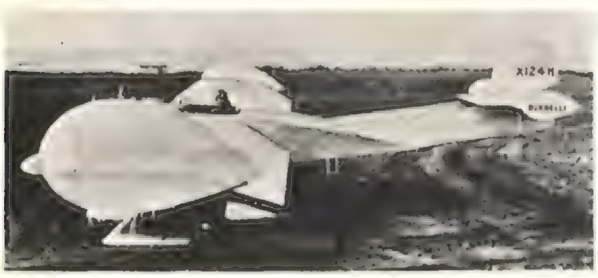

Burnelli's Lawson Airliner (top) didn't incorporate the lifting-body feature. But his GX-3 did, and it caught Jimmy Doolittle's attention.

Boeing developed for a company headed by Ed Cole, former president of General Motors. The Husky did indeed have a Burnelli-style airfoil-shaped fuselage. (In fact, the Boeing patent filing on the 754 cites Burnelli's earlier patents.) A spec sheet on the 754 surreptitiously mailed to Goodlin by a Boeing engineer showed that, using the same engines as the 767, the 754 had double the 767's payload.

Goodlin promptly fired off a letter to Boeing asking about royalties; Boeing attorneys sent back a series of increasingly testy letters. The 754 project was eventually shelved—according to Goodlin, to save Boeing the embarrassment of admitting the superiority of the Burnelli concept and to avoid paying him royalties. In a gesture of conciliation, Goodlin offered to drop the matter if Boeing would (*a*) take out a full-page ad in *Business Week* apologizing to him for stealing the Burnelli concept for the 754 design, and (*b*) donate $50 million to an air safety organization designated by Goodlin.

Boeing opted not to comment for this article. "We're a little skittish on the whole subject of Burnelli," a Boeing spokesman said.

Goodlin describes evasive treatment by other aerospace companies. He cites as an example a Northrop engineer who wanted to submit a Burnelli design for a Naval design competition. Management killed the deal, transferred the engineer, and told him never to talk to Goodlin again. Goodlin says Northrop was edgy because the Stealth bomber has Burnelli characteristics.

A Northrop source confirms the outline of Goodlin's tale but says, "Slick didn't just shoot himself in the foot, he shot his whole foot off. Things were going just fine until he wrote an aggressive legalistic letter to Tom Jones, the chairman. The whole thing blew apart when

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it hit top management. Slick shoots from the hip, and that prevents him from being taken seriously."

"The whole aerospace industry is interconnected, and they'll do anything to stop us," says Goodlin. "We have enough evidence for a criminal conspiracy." (He sued the Department of Defense in 1984 but has since withdrawn the suit.) "Things haven't changed since the 1920s. They're still a bunch of rotten bastards."

Since there are no Burnelli airplanes in flying condition, it's difficult to evaluate Goodlin's claims of superior performance. According to contemporary editions of Jane's *All the World's Aircraft,* performance of the early Burnelli CB-16 and UB-14 was comparable to similar aircraft of the day. The most modern Burnelli, the CBY-3, though close in power and payload to the Douglas Super DC-3, was a good 40 mph slower.

On the other hand, Goodlin points out with glee that Boeing's own spec sheet shows that the 754 Husky would have had greater payload capcacity than the 767. But the Husky had 31 percent more wing area and a higher aspect ratio—the ratio of span to average chord, a measure of the "skinniness" of the wing—than the 767, two factors that, entirely aside from its Burnelli-style fuselage, would give it a big weight-lifting advantage. Moreover, the Husky would have cruised at just Mach 0.74, compared with the 767's Mach 0.80.

According to standard aerodynamic theory, the "extra lift" provided by a Burnelli fuselage is, under most conditions, beside the point. A Boeing 767 cruising at 41,000 feet doesn't need extra lift from the fuselage. Its wing easily provides all the lift necessary to balance its weight. (In engineering terms, the aircraft cruises at well below the wing's maximum lift coefficient.) The designer's task is to get that lift with the least drag. It happens that a high-aspect-ratio wing (long and skinny) has inherently less induced drag than a low-aspect-ratio lifting surface (short and fat, like a Burnelli fuselage). In cruising flight, the less the fuselage lifts, the lower the induced drag.

Conventional wisdom also dictates that a Burnelli jetliner would suffer drag penalties because of its larger frontal area, larger wetted area (the area over which air flows), and the discontinuity

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The CBY-3 Loadmaster (left) was the last Burnelli built and the only one surviving. Slick Goodlin (right), chairman and president of the Burnelli Company, says the Loadmaster was the best-flying airplane he's ever encountered. If he has his way, the CBY-3 will have descendants like the proposed GB-178. Burnelli supporters say such airplanes would endure crashes better than today's airliners.

COURTESY CHALMERS H. GOODLIN

between the lifting fuselage and the wings. NASA aerodynamicist Jerry Hefner comments: "I would think the induced drag would be horrendous. And your skin friction drag is going to go up because of the larger wetted area." An engineer from a major aerospace firm who asked to remain anonymous (to avoid angry letters from Goodlin) estimates the drag penalty of a Burnelli-style jet transport at about 20 percent more than that of an airplane like a 767. That may be a reasonable compromise for a bulky cargo carrier like the Husky, but not for a passenger jet.

Slick Goodlin, of course, has never let conventional wisdom get in his way. "Boeing and Douglas and all the rest of them are simply wrong," he declares flatly. "The aerodynamics textbooks have been misinterpreted for 50 years."

Goodlin and established aeronautical theory do agree on one thing, however: the extra lift of a broad, flat, airfoil-shaped fuselage can theoretically reduce landing speed. Goodlin correctly cites the takeoff and landing speeds of current jetliners—typically 140 to 180 mph—as potentially dangerous. All of Burnelli's airplanes, by contrast, had low landing speeds.

But an airplane's landing speed is essentially a market decision, one of the tradeoffs in aircraft design. If Boeing had wanted the 747 to take off at 100 mph in 3,000 feet, it could have simply enlarged the wing and limited the weight. But since the major cities of the world all have 10,000-foot runways and since there is no great public clamor for slower, safer landing speeds, Boeing saw no reason to pay the speed, payload, and cost penalties of a short-takeoff-and-landing 747, Burnelli or otherwise.

Goodlin may not win many converts to his aerodynamic theories, but he's on much firmer ground when he criticizes the modern jetliner's crashworthiness. Goodlin says the Burnelli's rigid box-like fuselage would protect passengers in a crash, pointing proudly to the 1935 crash of the UB-14. The airplane hit the ground, wingtip down, at 130 mph and cartwheeled. Engines, wings, and tail were ripped off, but the boxy fuselage remained intact and the crew walked away. One vocal Burnelli proponent, Edmund J. Cantilli, professor of transportation planning and engineering at the Polytechnic Institute of New York, has decried the poor crashworthiness of the modern jetliner and proposed a Burnelli-style craft in its stead.

In 1986 Goodlin enlisted the aid of Florida senator Lawton Chiles, who persuaded the Air Force to invite Goodlin to Wright Field for a speech about the Burnelli concept. Goodlin promptly demanded that the engineering vice presidents of Boeing, Douglas, Northrop, and Lockheed be in the audience. These are the people who need to hear his message, he says. "They care nothing for principle, ethics, or integrity. They care nothing for the number of people unnecessarily killed. They will even jockey us into war if it means preserving their power and greed."

And so Goodlin continues to wage his holy war on all fronts. Like most holy warriors, he seems to savor the call to battle more than the promise of victory. "I hate to say this about Slick," says one Burnelli supporter, shaking his head, "but darn it, I wish he'd simmer down a little. He'd accomplish a lot more."

The Last Flight of Professor Donaldson

On a summer afternoon in 1875, the United States' premier aerial showman took off on another attention-getting balloon flight. Was he looking for just another thrill—or a way to end his life?

by Donald Dale Jackson

The daring young man on the flying trapeze dazzled audiences with his ruddy good looks, gaudy costume, and high-altitude gymnastics.

The crowd that had gathered at Chicago's Dearborn Park on July 15, 1875, was a riot awaiting a spark. The advertised attraction was balloonist Washington Harrison Donaldson, America's premier aerial showman of the day, and on this sultry Thursday afternoon he planned to waft across some 120 miles of Lake Michigan.

The thousands of unruly spectators who surrounded Donaldson's cotton gas bag gave off an aroma that the *Chicago Tribune* described as part rum, part plug tobacco, and part herring. Hooting and swaying, they pressed forward, nearly engulfing the balloon and its pilot while a band brayed cheerfully nearby. The 34-year-old Donaldson, who was whistling vacantly and staring at the sky, was described by the *Tribune* reporter as "short and very square-shouldered, with a gymnast's breadth of chest and big-jointedness. His coat collar was turned up to shield a large, muscular neck from the sun," and a silk hat was pulled low over a face "brown as a berry, with hair cropped short, a thick dyed mustache twisted up in an inquisitive point at each end, and a pair of bright dark eyes which roved hither and thither."

Bolder members of the throng taunted Donaldson, occasionally eliciting a reply that the *Tribune* characterized as "an exposition of the ruder vernacular." But when a mocking voice cried, "Donaldson, you better get out!" the balloonist's muttered response was heard by only a few. "I wish to Christ I could," he said.

"Professor" Donaldson was not America's greatest balloonist, nor the most scientifically sophisticated, but he was the most entertaining. He took up ballooning after 14 years of touring as a magician, ventriloquist, and tightrope walker. In 1871 a client offered a small, threadbare balloon in exchange for magic lessons and magician's props, and Donaldson, whose hole cards had always been his balance and courage, instantly saw the possibilities. He abandoned tightrope walking, strung a trapeze bar beneath the small balloon, and declared himself an aeronautical acrobat.

While barnstorming around the east for the next two years,

In a thinly veiled advertising stunt, Donaldson presided over the wedding of two fellow circus employees one mile above Cleveland, Ohio.

he polished his act. Dressed in flesh-colored tights, a purple satin shirt, and blue kid boots, he would stand jauntily on the trapeze as the balloon lifted off. At two or three thousand feet—a glittering speck to the audience—he would launch into a series of leaps and flips. As a climax he would fake a fall and then catch one foot in the trapeze, leaving the crowd gasping. Then he would appear to fall from the trapeze altogether, saving himself by grabbing a rope at the last second. The Professor was box office dynamite. No wonder, then, he was snatched up by that preeminent merchant of marvels, Phineas T. Barnum.

Donaldson was the gilt-edged attraction in Barnum's Hippodrome circus, but his character went beyond flamboyance. He lusted after danger, thrived on it, demanded it. He was "a man who never felt a nervous thrill," the *Cincinnati Commercial* said. Eventually, his need to take risks became inseparable from the crowd's need to see him do so, and he gave them what they wanted.

Barnum had persuaded Donaldson to abandon his trapeze, however, and concentrate on carrying journalists in the *P.T. Barnum* balloon. It was a benevolence that invariably paid off in publicity but was pretty tepid stuff for a daredevil. Hippodrome management realized that a suitably perilous flight plan might at least hold his interest, and thus the flight across Lake Michigan was arranged.

Ground crewmen held the mooring lines taut as the liftoff time approached. Shortly before 5 p.m. young Newton Grimwood of the *Chicago Evening Journal* and James Maitland of the *Chicago Post and Mail* shouldered through the line of cigar-chewing police and climbed into the wicker basket. Assessing the *Barnum*'s patched envelope and the resulting reduction in lifting power ("a leaky old tub," an older and wiser balloonist later described it), Donaldson decreed that only one could go. Grimwood won the draw. If Donaldson was aware of the forecast—falling barometer, increasing clouds, and rain—he kept it to himself.

Finally all was ready. The crew released the lines and the *Barnum* bobbed a few feet off the ground and lurched from side to side, sending the crowd reeling backward. Grimwood, peering through the netting above the basket, looked like a caged and frightened bird. At Donaldson's command he turned over a ballast bag and spilled sand on the upturned faces below, then began tossing out handbills advertising Barnum's circus. The band blared on as the balloon slowly rose. Donaldson waved his hat as the globe hung for several minutes over the

A night flight over Lake Ontario was nearly the last for Donaldson, three reporters, and the P.T. Barnum.

Early in his career, Donaldson's balloon burst above Norfolk, Virginia, and the balloonist plummeted into an oak tree.

shore and then floated gently upward to the northeast. Ten minutes later it was out of sight.

"The direction taken by the balloon and the force of the wind indicated that it would probably land somewhere in Michigan," said the next morning's *Tribune.* "At a late hour last evening nothing had been heard from it."

Ballooning, like gymnastics, tightrope walking, and other skills requiring balance, coordination, and a dash of daring, came naturally to Donaldson. As a boy growing up in Philadelphia, the alderman's son used to entertain playmates by running up a precipitously balanced eight-foot ladder. "Wash," as he was known, began performing as a gymnast and tightrope artist, then traveled with a minstrel troupe as a magician and knife thrower.

But it was ballooning that completely captivated him. "The moment the ropes are cut," he said in a rare attempt to describe its appeal, "all is perfect repose and stillness the most profound." His first ascent, in a patched-up vessel called *Comet,* acquainted him with both the joys and the awkward surprises of the sport. The view of the countryside, the smooth passage above the trees, the sense of freedom—all this thrilled him. But he also got stuck on a rooftop while trying to climb and had to dump all provisions, including hat, coat, and boots, to gain altitude. His next flight—the first on the trapeze—ended abruptly when, while releasing gas from the envelope, he tore it, fell rapidly, and smacked into an oak tree. Nonetheless, he was smitten—and so were the crowds. A review of that performance notes that people stared skyward in awe "until the blood ceased to curdle in [their] veins . . . , and they gave vent to their feelings in cheer after cheer." Wash was clearly onto something.

Donaldson continued to flirt with fate. On a flight from Norfolk, Virginia, in January 1872, the valve that released the balloon's gas froze at altitude. Donaldson clambered up the netting that covered the balloon, opened a pocket knife with his teeth, and sliced the envelope. He then lashed himself to the ring of the balloon above the basket and plummeted into a cornfield. After being dragged a thousand feet he collided with a fence, which knocked him unconscious and shredded the balloon. The following spring he flew a balloon built of varnished manila wrapping paper at Reading, Pennsylvania. As if this weren't sporting enough, he offered to set it on fire and parachute out for a $1,000 fee, but no one was buying. His first appearance in Chicago, on the Fourth of July, 1872, came to an inglorious end when he was dumped in Lake Michigan and dragged through the water at the speed of a nearby train while its passengers waved their hankies at him. He was finally halted by a stone jetty.

But for Donaldson and other balloonists, the exhibition flights and one-night stands that put food on the table were not enough. The real glory—and the prospect of aerial immortality—lay in an Atlantic crossing. The English Channel, the Alps, and a sizeable chunk of Europe had been traversed by balloonists, but none had conquered the ocean. Donaldson set out to do so in 1873.

John Wise, dean of American aeronauts, had been seeking backing for a transatlantic flight for 30 years. Wise was certain there was a high-speed west-to-east air current—later known as the jet stream—that would propel him across the ocean in three days if his balloon could gain some three miles of altitude. Donaldson was thinking along the same lines, envisioning an enormous and elaborate balloon with a 268,000-cubic-foot capacity. The 65-year-old Wise offered to join him, and together they won the endorsements of the prestigious Franklin Institute of Philadelphia and the Smithsonian Institution's secretary, Joseph Henry.

The Goodsell brothers, publishers of the *New York Illustrated Graphic,* agreed to finance the effort—which they termed "one of scientific inquiry and not for private gain"—in exchange for an exclusive account. But a month before liftoff day Wise suddenly backed out, disgusted with the Goodsells' blatant commercialization of the effort and the balloon's shoddy construction. Donaldson carried on, laying in 30 days' supplies—meat, eggs, coffee, sardines, canned fruit, brandy, fishing tackle, tools, carrier pigeons, pomade—and collecting travel documents for European countries.

By September the 11-story balloon—named, of course, the *Great Daily Graphic*—was ready for inflation. The first attempt was aborted after the balloon dragged 20,000 pounds of ballast and the entire ground crew across a Brooklyn exhi-

bition site. During the second attempt two days later, the balloon burst. The Goodsells gave up and donated the remains to Donaldson, who used them to patch together the *New Graphic,* half the size of the original. Finally, on October 6, Donaldson and two *Graphic* reporters took off, a lifeboat dangling beneath the gondola. They drifted north, then east over Long Island Sound toward Connecticut and foul weather. Rain pelted the *New Graphic's* muslin envelope, and swirling winds sent it spinning near the treetops. Out of ballast, Donaldson tossed out a box of hominy to keep the balloon airborne. They were gyrating wildly over a hillside in North Canaan, Connecticut, when he ordered all hands to abandon ship. Four hours after departing Brooklyn, Donaldson and one reporter jumped 30 feet to safety; the other newsman bailed out a few miles away. A place in history had eluded him, but Donaldson managed an optimistic front. "I can only say that I will yet do this thing," he declared. But the next summer he went to work for the Greatest Show on Earth.

As a featured attraction in the Hippodrome show, Donaldson was an eagle with clipped wings. His association with the century's greatest showman guaranteed fame and income, but it also diminished him. Playing one day in Springfield, Massachusetts, another in Portland, Maine, yet another in Providence, Rhode Island, and Buffalo, New York, ferrying journalists and dignitaries on one tame ride after another, Donaldson became just another curiosity in Barnum's menagerie. Gone were contortions on a high-altitude trapeze; no longer could he invent new and daring stunts whenever the impulse seized him. The work demanded so little that he frequently fell asleep while piloting a bunch of popeyed reporters.

Where once he had derided his audiences for their bloodthirstiness ("People flock in thousands to see me break my neck," he said), he now seemed to turn his scorn on himself. The failure of the transatlantic flight robbed him of a niche in history, and now Barnum was nudging him into obscurity. His professional self-esteem suffered too: the pace of life in a traveling circus left Donaldson little time for keeping his balloons properly repaired and airtight.

Through the summer and fall of 1874 he toured through New York, Boston, Philadelphia, Baltimore, and Pittsburgh. A widower with two young children, Donaldson became engaged to Maggie Taylor, a bareback Percheron rider with the Barnum troupe.

Reporters liked him for his intelligence and charm as well as his courage. They saluted the "remarkable fertility of his mind" and "a nature from which the elements of fear and timidity seem excluded." But Donaldson was also distant and unreachable. His expression when confronting a crowd, one paper said, was "a copper mask." He became rash: on a flight from Philadelphia he tossed out an anchor when the gas valve rope proved unreachable, cut the basket free of the balloon, and fell 75 feet, knocking himself out and inspiring a report that he had been killed. In Toronto in June 1875, he took off with three reporters in the underinflated *Barnum* and was dragged across Lake Ontario in the middle of the night. "Well, boys, it's all up," he cheerily advised his passengers, but a passing ship sent a rowboat to rescue them. He seemed to be desperately tempting fate in the only way he had left.

For the first two hours the *Barnum,* bearing Donaldson and reporter Grimwood, sailed steadily northeast on a light breeze. The 22-year-old reporter, who had literary aspirations, jotted down phrases for his story. ". . . I have always had a presentiment that sometime, sooner or later, I was bound to *rise,*" he noted shamelessly, and "Like a great many politicians I rise by means of gas." He characterized Donaldson as "a very pleasant gentleman, although a philosopher and aeronaut" and mused over gloomier possibilities: ". . . if we fall, we fall, like Lucifer, out of the heavens, . . . —for we are over the middle of Lake Michigan—we would literally be DEAD."

At 7 p.m. the captain of the schooner *Little Guide* spotted the balloon 12 miles north of Chicago and about 30 miles offshore, in apparent distress. The skipper saw the basket of the *Barnum* strike the water several times, then rebound to only several dozen feet above it. As he sailed toward the balloon to offer help, it shot up as if a heavy load had been jettisoned: a few minutes later the *Barnum* was out of sight.

Donaldson seemed to be tempting fate in the only way he had left.

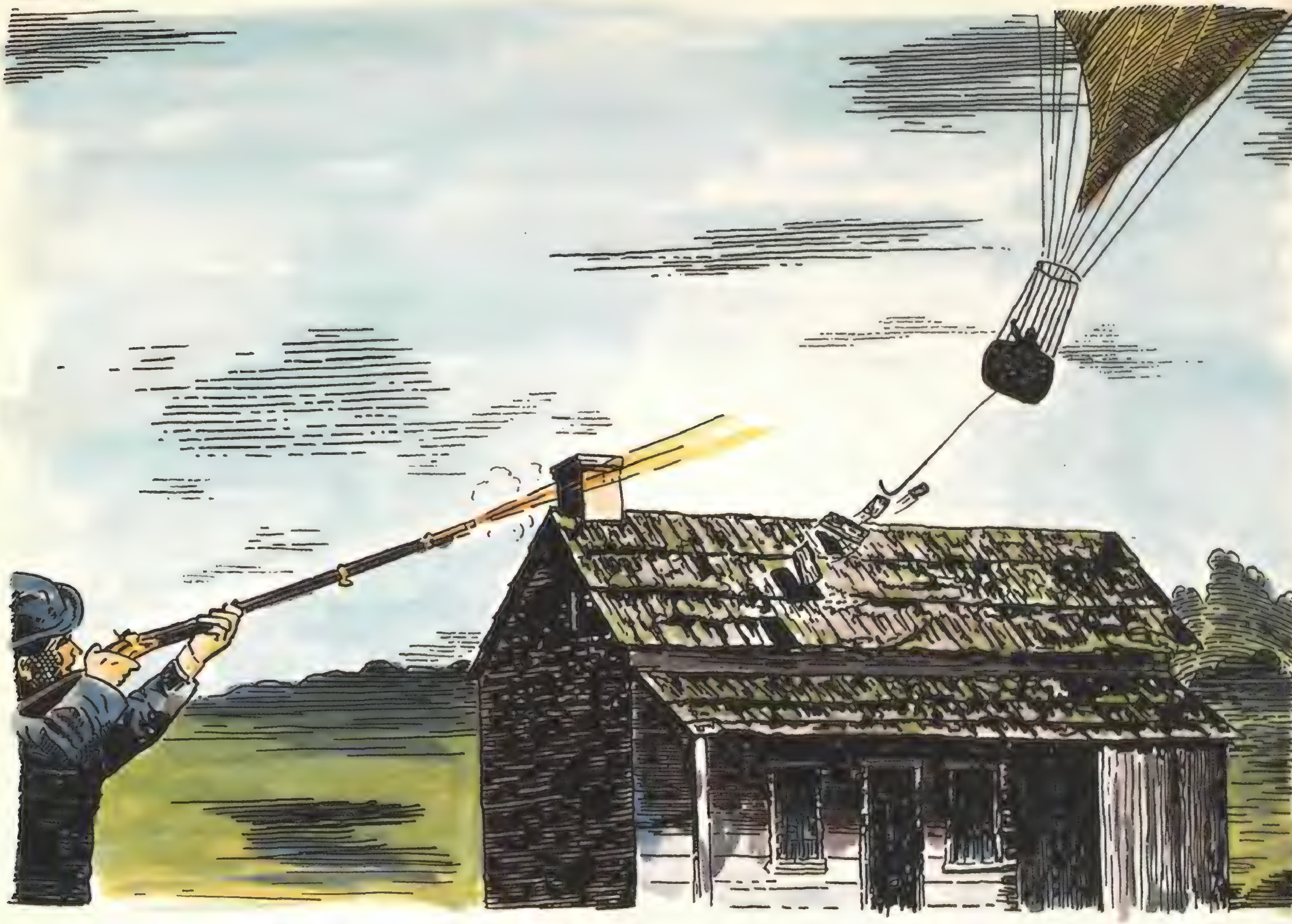
Around midnight the storm that had been building in the late afternoon began howling southward from the north end of the lake. Sailors who were caught in it reported high seas, gale-force winds, hail, and thunder. The fragile *Barnum* was riding it out alone; of all the ships on Lake Michigan that night, only the *Little Guide* reported sighting the balloon.

By midnight Friday there had been no word on the *Barnum* for more than 24 hours. A meteorologist the *Tribune* consulted estimated that the voyage should have taken no more than eight hours. Had Donaldson finally stretched his luck too far? The *Tribune* thought so, but maybe no news was good news. No trace of the balloon, the basket, or its occupants had been found, so perhaps they had made it to Michigan, stayed airborne until dawn broke, and found themselves in a stretch of wilderness. That was what P.T. Barnum chose to believe. Donaldson, he said through his press agent, had survived more perilous scrapes than this. Why, he was probably on his way back and might arrive in Chicago any minute.

Day after day the vigil continued. On July 19, four days after Donaldson and Grimwood's ascent, Chicago newspapers eagerly reported the sighting of a life preserver and something that could have been an upended basket about 50 miles offshore, as well as balloon remnants 20 miles from Chicago and a body west of Grand Haven. Reports now poured in daily: a Michigan railroad crew purportedly saw Donaldson, alone, on the southeastern shore of the lake, while witnesses in Aurora, Ontario, said they saw a balloon and empty basket passing northeast several days after the *Barnum's* takeoff. A ship's captain said he had seen the balloon skimming the water and heading *west* on that terrible night.

Gradually people grew convinced that the balloonists had drowned, that Donaldson had finally played out his hand and

TIBOR G. TOTH



A Maryland farmer took potshots at the Professor's balloon after it ripped shingles off his roof.

taken Grimwood with him. Ex-military and exhibition balloonist John Steiner, who knew Donaldson well, was certain that the two could never have survived the storm, especially in the tattered and patched *Barnum.* "Why, it would have taken the very best China silk to stand *that* racket," he told a *Tribune* reporter. The Hippodrome's Chicago manager denied that the balloon was in poor condition but added that if it was, it was Donaldson's fault. He offered a $500 reward for the recovery of either of the bodies. W.K. Sullivan, the *Chicago Evening Journal*'s city editor, who had looked on Grimwood as a protégé, spoke intemperately of "Barnum murder."

On August 17, just over a month after the disappearance, the papers reported that a mailman had found Grimwood's bloated and decomposed body on a beach near Montague, Michigan, some 25 miles north of Grand Haven. Around his waist was a broken life preserver, and in his pockets were identification cards and a diary with the notes he had scribbled over Lake Michigan. He was buried where he was found. A 20-mile search along the shore turned up nothing of Donaldson or the balloon.

What had happened? And where was Donaldson? Was he dead or alive? Journalistic vultures fluttered into the void. Within a week, the *Cincinnati Times* ran a sensational story about a man who claimed to be Donaldson being found gangrenous and near death in a hut along Ontario's Montreal River. He confessed, the paper said, to having thrown Grimwood overboard after the reporter pulled a derringer on him as the balloon descended in the storm. Though other papers eagerly reprinted the story, it was largely dismissed as a hoax. The more likely explanation was simply that the two men had drowned when the balloon was forced down in the storm. Both the *P.T. Barnum* and its melancholy pilot had probably sunk.

Was Donaldson, *in extremis,* capable of murder? The *Chicago Tribune* reported that "a careful examination of the body of Grimwood was not made to see if any signs of violence were visible." But based on the testimony of those who knew the balloonist, as well as the circumstances of his disappearance, it seems doubtful that he killed his companion. Washington Donaldson had spent a lifetime in search of narrow escapes; it's possible, judging from his behavior during the last months of his life, that narrow escapes were no longer enough, that the odds had to be prohibitive. Grimwood may have been the luckless passenger on a suicide flight. Then again, maybe Donaldson simply couldn't pass up a challenge.

On August 17, a news dispatch reporting the discovery of Grimwood's body was read to a hushed audience at the Hippodrome show in Minneapolis. Moments later Maggie Taylor, Donaldson's fiancée, climbed on her horse for the afternoon hurdle race.

Heroes

Cleaning out the attic of the old family house was a formidable task. It took three days to sift through all the junk that I could not bear to throw out as a child. Cub Scout trinkets, postcards, potholder looms, and the like passed through my hands for the last time on their way to garage sales, bazaars, and county landfills. In those three days, I relived nearly all my childhood.

The afternoon of the last day was a scorcher, the roof beams hot to the touch. I seemed to be forming a cement-like second skin as dust and dirt were wetted by glass after glass of iced tea that flowed from my pores. With only a small pile to go, I was mentally headed for the shower when I struck gold. In a fragile cardboard box, just beneath my worn copy of *Mr. Wizard's Science Secrets* ("Over 150 Mystifying Experiments You Can Do at Home"), lay the remnants of my first model airplane.

The box had arrived one summer day in 1953. Back then Daddy traveled all week as a salesman for a farm supply company, and Friday homecomings were always highlighted by a gift. That Friday, he and I had torn the wrappings off the box and inside discovered several blocks of balsa wood and a sheet of instructions that neither of us understood. We couldn't determine which block was destined to become the "fuselage," let alone what a fuselage was.

Daddy's salesman's instincts told him when he could close a deal himself and when he needed help. We bundled up our predicament and marched over to a neighbor who, though he had never flown an airplane, had once shot one down, saved his ship, and helped win The War. We heard the story again, as we knew we would, during an examination of the contents of the cardboard box, accompanied by much hemming and hawing and furrowing of brow. The upshot was that I became the proud owner of a 20-millimeter shell casing that had graced our neighbor's mantel—no doubt the one that had brought down the enemy, given the solemnity of the presentation.

Daddy had realized early in the visit that the solution to the balsa wood puzzle was not forthcoming here. Diplomatically, he boxed up the pieces, determined to go straight to the source—the local airport. Its overseer was one of many pilots who came home from the war having tasted freedom they would never have known as mill hands or farmers. He loved to fly—so much so that he tried to eke out a living at it even when drought kept his war-surplus Stearman crop duster grounded, its engine a haven for wasps, spiders, and birds' nests. Occasionally, I later learned, he did a little instructing or maintenance work, but most of his days were spent alone, the red clay

SUSAN DAVIS

dust of Georgia settling over his dreams and aging him prematurely.

My father and I ate breakfast together, as we did every Saturday, then set out in the old green Nash to learn what we could about airplanes. Just exactly what transpired with the box of balsa at the airport is long gone from memory, but any disappointment was quickly dispelled by the news that we were going on an airplane ride. If a good salesman gets caught in an undertow, he just goes with the flow and sells something else, which, I suppose, is why Daddy sold an awful lot of fertilizer.

I don't remember the type of airplane or how much the ride cost. But I do remember how smooth it was after we broke ground, and I remember looking down at the greens, blues, and yellows of the fields below, tinged red with the ever-present dust. I could pick out our town's main street, where I had finished second in the Fourth of July bicycle race. On one corner of the courthouse square stood the hardware store where I bought my Daisy Red Ryder BB gun. Then, in an instant, we were past the Br'er Rabbit Motel and over the pond at Chappell's Mill, where old tree stumps dotted the sparkling water.

Then I spotted our house, and the landmarks fell into proper order: over there was the park and the War Memorial pool, and further along, my school. And ever since that day when I sat beside my father, looking down on an eight-year-old's universe, I have wanted to fly.

Fate is kind to some, less than kind to others. The young Army Air Corps veteran who took us on that flight later lost his life in a flying accident. And I became a working pilot, the only job I ever truly wanted.

But the real hero of this tale is my father. Before that day in 1953 and ever since then, too, my father has had an abiding fear of heights. He came from a long line of farmers, responsible people rooted in the earth. Perhaps he knew that it was his responsibility to show me a new world, however alien and hazardous it was to him.

Not all heroes appear in books or on film. Most live quiet, unpretentious lives, their solid character displayed in the daily humdrum of ordinary tasks. On that sweltering afternoon in the attic I realized that my hero's gift had come with an obligation: to share the immense joy and satisfaction of flying with others.

We all have gifts to give. The greatest come from the heart—and go to the heart—often without the giver's knowledge of their true value. These are the gifts that brighten our days, widen our horizons, and, in rare cases, plant the seeds of our future.

—Alex Nelon

From Slinkies to Space Horseshoes

MICHAEL DAVID BROWN (5)

My brother Ralph and I never quite saw eye to eye on toys. His rubber duck was a bath toy. My plastic penguin was a companion. I rolled my gyroscope, sometimes spinning, on the floor. He danced his on its string and atop the metal Eiffel Tower that came with it.

Ralph now studies planetary geology and atmospherics at NASA's Jet Propulsion Laboratory in Pasadena, California. He is an expert on inner solar system climatology. I write magazine articles on cities and housing. Mine is a quirky world of legal loopholes where behavior leans toward the erratic. His world is governed by the laws of physics, where neither bureaucrats nor bribery can alter the operation of a gyroscope or the force gravity exerts on a satellite. It took years for our professional paths to cross. Still, common turf was out there, rooted in childhood but located in space.

Ralph discovered it a few years ago when he started a project he calls "Toys in Space: Fun Things to Do in Zero Gravity." It was a lark that became a hobby, and out of it came five theoretical playthings for astronauts: toys that offered the promise of space play and also served as a reminder that Earthly gravity shackles our imaginations as well as our bodies.

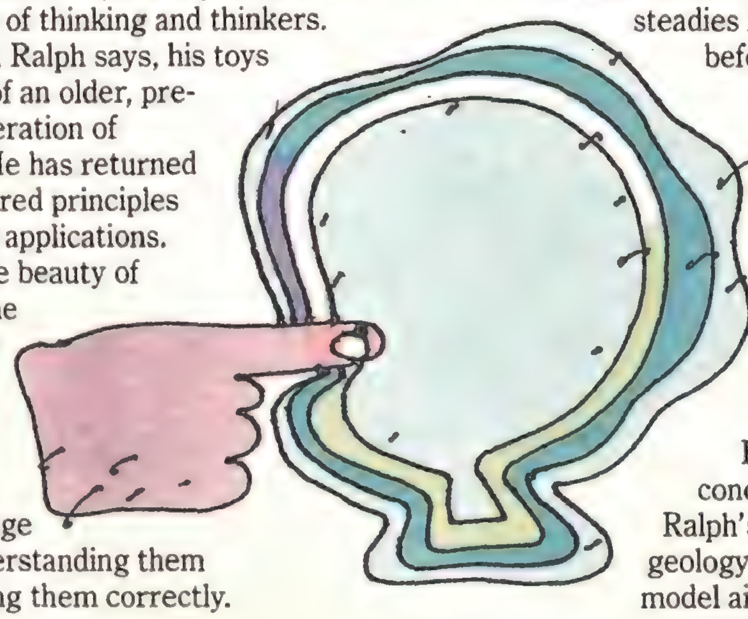
A couple of hundred miles up, where gravity thins to a mere suggestion and floating is the norm, Ralph's ideas come to life. Take a Van de Graaf electrostatic generator—the mainstay of mad scientists in horror movies—and crank it until the upper sphere has a good charge arcing between the two conducting rods. Now toss marble-sized balls of pith at it, guessing at a speed and trajectory. Ralph calls this Space Horse Shoes, and according to his reading of the prevailing laws of physics, if you pitch right the balls will enter a stable orbit around the charged sphere.

His Springo set is the first improvement on the Slinky since Richard James stumbled upon it almost 50 years ago. (James was developing fast-acting springs to improve the mounts for nautical instruments. According to the lore, he accidentally knocked one of his creations off a shelf and discovered the recoiling motion that has made the Slinky an institution.) For space play, Ralph decided, the Slinky's single coil had to go. He came up with Springo, a collection of open linear springs and brightly colored connectable spheres that is half Slinky, half Tinker Toy. You build geometric forms with them and then, Ralph writes, "by extending, compressing, and spinning the objects . . . [y]ou can observe the remarkable behaviors of two and three atom 'molecules,' or the complex oscillations possible with, for example, a cube."

Ralph began his toy box and the redesign of the Slinky in 1986, not long after seeing *Toys in Space,* a videotape produced by NASA and Carolyn Sumners of the Houston science museum. Part of the Teacher in Space program, it was filmed in April 1985 when the shuttle *Discovery* carried into orbit 14 tons of cargo and a box of toys, including a top, a yo-yo, a paddle ball, and a Slinky. The idea was to help teach physics by getting students to speculate on how terrestrial toys would behave in microgravity, then observe what actually happens. "Toys are really a good way of gaining deeper understanding of a new environment," Ralph says. "You find new arenas and you play in them until you figure out how things behave." After watching the tape Ralph concluded that were it not for gravity the Slinky would never have sold.

"We are beginning to change the way we think of space," says Frank Hughes, head of NASA's space station training office in Houston. We are no longer just visitors on orbital jaunts—we are moving in, and we will have time on our hands. NASA, says Hughes, has begun studying the importance of play for the long-term space traveler. Ralph's toys, he says, are part of a new generation of thinking and thinkers.

Actually, Ralph says, his toys are those of an older, pre-gizmo generation of thinkers. He has returned to uncluttered principles and simple applications. "That's the beauty of physics," he says. "The concepts tend to be fairly simple, so the challenge lies in understanding them and applying them correctly. Once you've got it, the results always seem obvious. It makes it hard to imagine that no one else thought of it before."



Ralph was at Washington University in St. Louis, studying the climates of Mars and Venus, when the NASA toys-in-space tape inspired him. He raised the issue with people at the university and at the St. Louis Science Center. One of the first things he discovered was that thinking about space as usable, particularly for laymen, requires a certain amount of mental gear shifting. "When most people start off, their thinking is not structured enough to come up with ideas that go beyond what they've seen mostly in science fiction movies and sometimes in NASA videos," he says. Three-dimensional chess, played on Star Trek's *Enterprise,* is a typical entry from beginning space toy designers. But after focusing on the differences between Earth and space, on Newton's laws concerning objects in motion and actions resulting in equal and opposite reactions, imaginations are piqued and people start thinking up unique sorts of ball games—variations on racquetball and squash, for example. "That's when they start getting excited," says Ralph. "Without a lot of engineering and technical background, they have something they can think about."

Take, for example, Ralph's Moving Targets. The two-player version employs spheres the size of Ping-Pong balls covered with Velcro and embedded with magnets, and a dartboard-like target held like a shield. Between target and tosser is a six-inch bar electromagnet designed to deflect the sphere's path. The catcher uses the magnet to deflect the ball and score high, while the thrower tries for as low a score as possible.

The Blob is a basketball-sized balloon filled with gel and embossed with a grid. On Earth it would be a water balloon. In microgravity it resembles its planet of origin: its core is liquid, its surface somewhat flexible, and spin stabilization steadies it. "Spin it and you have before you the oblate spheroid of grade school fame," Ralph writes. Poke the spinning Blob "and you can simulate earthquakes or recreate some aspects of a collision between the Earth and an asteroid."

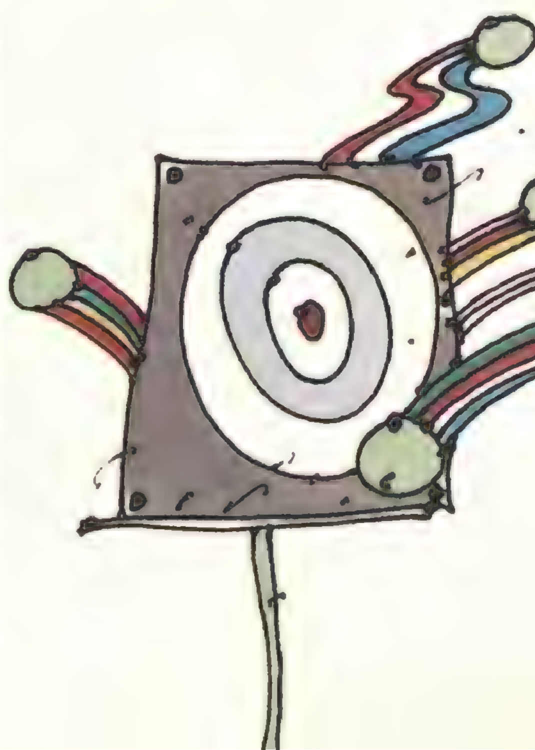
Lastly, there is the Peneplane, a balsa wood concoction inspired by Ralph's early years spent with geology books and dimestore model airplanes. In geological

terms, a peneplain is a plateau that has been eroded almost into a plain. The wingless Peneplane is a severely distorted airplane: two variable-pitch propellers, powered by a rubber band, are mounted at either end of a foot-long balsa stick. On Earth it would tumble to the ground and writhe like a beached flounder. In the shuttle cabin's atmosphere, however, the competing propellers make it a stunt flier.

Ralph spent about two years creating his five toys. Ideas came slowly; questions, rapidly. For instance: What can we do in a vacuum? "None of these toys really take advantage of the vacuum," he says. "We understand microgravity as well as we do because of the experience we have had with buoyancy. Astronauts train in swimming pools, and we've used that experience to design huge structures that take advantage of the fact that in space, weighty objects can be moved with fairly little force. But then there is the vacuum. As an environment, we really know very little about it. We don't know how to use it in any meaningful way, so we have to expend effort fighting it."

That will change, Ralph predicts. Meanwhile, he is talking with NASA's astronaut corps, exploring the possibility of getting some of his toys on a shuttle flight. Eventually, perhaps, he'll come up with a toy that will do for the vacuum what the rubber duck did for the bath.

—Roy Kahn



The Black Watch: The Men Who Fly America's Secret Spy Planes *by Ernest K. Gann. Random House, 1989. 210 pp., $18.95 (hardbound).*

It's only fair to tell you, before I begin this review, that I worship Ernest Gann. Reading *Fate Is the Hunter* in college convinced me that I should learn to fly. Three months later I enlisted in the Naval Reserves with a guarantee of flight school when I graduated from college. I have

never regretted my decision. I firmly believe that Ernest Gann is the world's greatest writer about those who fly. In addition to *Fate,* Gann has written such classics as *The High and the Mighty, The Aviator, Band of Brothers*—over 20 books in all, most of them huge best-sellers and all of them terrific. He has claimed the sky the same way that Hemingway seized the sea and the bullring. His work is the standard against which others are measured.

In his latest gem, *The Black Watch,* Gann tells the story of present-day U.S. Air Force U-2 pilots. The U-2 is the fabled Lockheed skunkworks spy plane that the late Francis Gary Powers rode to ill fame and worse fortune back in 1960. I had assumed, perhaps naively, that the high-flying U-2 reconnaissance jets had long ago been replaced by spy satellites and retired to the Davis-Monthan boneyard. Not so. They are still flying, though their monkish attendants normally live in highly classified anonymity. Somehow Gann talked his way into the Beale Air Force Base monastery in California and flew four times in the U-2.

The book that Gann has given us is almost as odd as the airplanes he is writing about. Billed by the publisher as non-fiction, the first 35 pages seem straightforward enough—literate, explanatory narrative. Then the book takes a hard right and Gann adopts the style of the novelist. The remainder of the book, though still presumably nonfiction, reads like a novel, with dialogue and flying and women and all the trimmings. Amazingly enough, this abrupt change in narrative style works quite well, no doubt because Gann is an absolute master of both styles.

However, those who insist on reading this book as a novel will be disappointed. There is no plot. This book is *not* a taut aviation thriller like *The High and the Mighty.* We meet the people, learn their problems, and see them flying U-2s and functioning in their world, but the only tension is that inherent in flying.

What Gann has achieved is the best story about today's peacetime military aviators I have seen. The people, the problems, the bureaucracy, the flying, the families—he captures all of it in a story that is easy to read and devoid of pretension.

In a larger sense, the book is about a great deal more than U-2 pilots. Here is how Gann so carefully states it:

"We cannot continuously lie with our love, because if we do the fire of enchantment falters and eventually becomes cold. All artists know this, and some aviators. A very few consciously seek a substitute, but the large majority simply allow a rival interest to take center stage now and then, providing the basic scenery is not changed. Yet although we may temporarily turn away from obsession, recapture is inevitable and tends to become all the more binding. Flying is an almost fierce obsession. For the true believer it leaves only crumbs of the heart for other things."

Thank heavens one of the other things Ernest Gann loves is writing.

—Stephen Coonts writes flying novels himself. His latest, The Minotaur, *is due out in October from Doubleday.*

High Honor *by Stuart Leuthner and Oliver Jensen. Smithsonian Institution Press, 1989. 432 pp., $19.95 (hardbound).*

Historians seem irresistibly drawn to the major conflicts of World War II, which may explain why there is so much in print about such battles as Midway, Coral Sea, and the Battle of the Bulge. Even fictionalized accounts of the war tend to ride the waves of grand events, which carry their players along like helpless passengers on a whitewater raft.

But in this account, compiled by two determined people armed with tape recorders, the picture that emerges is so different you find yourself wondering whether they're writing about the same war. Stuart Leuthner and Oliver Jensen spent years gathering remembrances of the air war experience. The World War II that emerges from these accounts is to conventional histories what the view through a microscope is to a snapshot.

Twenty-eight people tell their tales, which range from the recollections of Josephine Rachiele, a riveter at the Republic Aviation plant on Long Island, to an account by Thomas Lanphier of the secret fighter mission to find and shoot down Admiral Isoroku Yamamoto—including Lanphier's thoughts on the controversy over whether he deserves credit for downing the admiral's transport. Their words seem to have been printed exactly as they were uttered, producing a quilt of many voices.

The tales in *High Honor* reveal a war in which individuals were largely responsible for their own fates. Their initiative, their successes and failures, determined the outcome of combat. Although they were aware of mighty armies engaged in distant clashes and apprehensive about the war's outcome, their own experiences were more likely to be much smaller actions characterized by combat with a lone enemy. Generals command great forces from afar; the individuals we meet in this book looked the enemy in the face.

They trained for endless weeks, then waited. They boarded ships for month-long voyages into a combat zone that sometimes offered only more tedium. They recall their fears when they finally encountered the foe, the decisions—more like reflexes—they made in the heat of battle, and their feelings in the aftermath.

Leuthner and Jensen have allowed their subjects to extend their biographical accounts to postwar events, which lead, in many instances, up to the present. At first the relevancy of this material seems questionable, but as the tales accumulate, the point becomes clearer: war changes people, then ends, and the people get on with their lives. What connects them henceforth is the altered states in which they go on: the ways in which their values are jarred and realigned by the scramble to survive. For most, postwar life can't begin to match what they'd experienced, and while a few seem to shudder at their memories, many embrace them.

The authors deserve credit for stalking shy game. The people who are most likely to have something worthwhile to say about their war experiences are sometimes the least likely to volunteer it, and Leuthner and Jensen apparently created an atmosphere in which their contributors felt comfortable speaking from the heart. Their subjects' willingness to enter the confessional booth varies; some seem to go about their task with a sense of duty, telling their stories for future generations, while others seem to be unburdening themselves. And there are moments in this book when you sense the storyteller pulling back at the last moment, avoiding some memory too painful to encounter.

Although the stories are grouped into eight sections, they could have run in any order. Some of the names are recognizable: CBS broadcaster Hughes Rudd, commuter airline founder Dawson Ransome, editor-publisher Robert Parke, educator Roscoe Brown. They may be listed in *Who's Who* now, but their appearance here actually drives home the point that war is a great equalizer. If you regard *High Honor* as a kind of reunion of aviation veterans, it is easier to see that it's their past experiences, not current circumstances, that unite the group. It's one reunion worth attending.

—George C. Larson is the editor of Air & Space/Smithsonian.

Bush Pilots of Alaska. *Photos by Fred Hirschmann, text by Kim Heacox. Graphic Arts Center Publishing Company, 1989. 144 pp., color photos, $35 (hardbound).*

"This is a book about the American spirit," the book's jacket tells us; "about a land so big and beautiful it defies description, and about men and women who love nothing more than to climb into their small planes, turn over the prop, and fly over that endless land. Each page is a vicarious thrill . . . ."

Fortunately, the book goes beyond such hype and hoopla. A more apt title could have been *Bush Planes of Alaska* since the majority of photographs are of airplanes rather than pilots. But there's another strong subject here as well. From the knife-edge sharpness of a red Cessna standing against the stark clarity of Denali to the surreal, ghostly airplanes haunting a frozen Anchorage lakeshore during a winter moonrise, Fred Hirschmann's photos overpower us with the *real* subject—Alaska's awesome land.

The text—including selections by former Alaska governor Jay Hammond and former lieutenant governor Lowell Thomas Jr., both pilots—provides a good, informative balance to Hirschmann's artistic point of view. From flying climbers to the slopes of

Mt. McKinley to supplying 300 Big Macs to a McDonald's-less town, the Alaskan bush pilot provides the necessary human connection for activity ranging from the mundane to the magical.

As all bush pilots know, there is something about Alaska flying that remains close to the bone, near to the essence of flight. And, as Hirschmann's photos repeatedly remind us, the magnificent scenery gets thrown in for free.

—Robert Reinaker has been an Alaskan pilot for 14 years.

***Soviet SST** by Howard Moon. Orion Books, 1989. 288 pp., b&w photos, $24.95 (hardbound).*

The crash of a MiG-29 at the Paris Airshow last June must have brought back bitter memories to some Soviet and French officials, not to mention the inhabitants of the village of Goussainville, who had

suffered a harrowing Soviet air accident 16 years earlier.

Pilot Anatoly Kvotchur's MiG crashed in a deserted area and he escaped death, but the crew of the last Soviet aircraft to experience a major mishap at the prestigious show was not so lucky. On the final day of the show—June 3, 1973—the second production Tu-144, the first Soviet supersonic transport to appear in the West, blew apart in the air, killing its six-man crew and eight people on the ground.

In this interesting book, Howard Moon,

dissenting from the consensus, argues that the cause of the crash was mainly political rather than technical; the battle of prestige between the Tu-144 and the French Concorde, he writes, led the show's organizers to demand at the last minute that the Soviet SST shorten its demonstration flight to allow the Concorde more time, enabling it to fare better in comparison. That move disoriented the Soviet crew, which already had to deal with a strange airfield in an aircraft with poor cockpit visibility.

It is fitting that a politically caused crash should have hastened the end of the Soviet SST effort since the birth and life of the Tu-144 were political as well. Premier Nikita Khrushchev, buoyed by the success of Yuri Gagarin's spaceflight in April 1961 and the introduction in July of two new Mach 2 interceptors and the M-50 supersonic bomber, announced in October a new Party Program filled with technological projections. Superior technology, including the SST, was to boost Soviet productivity and standard of living past the levels of the capitalist West.

When the Soviet Union boasted that it would be the first nation to inaugurate SST travel, it was counting on its ability to quickly convert its M-50 bomber into an SST by inserting a passenger pod in it. It wasn't that easy. Unfortunately, learning that lesson took 25 years, the lives of a number of test pilots, and more than $4 billion.

While the Soviet space program's victories were founded on years of research, experimentation, and relatively well-known technology, the Tupolev design bureau had to work with tricky new technology at a pace dictated by politicians' whims. Although the Soviets delivered on their promise of launching the first SST flight, they were not able to solve problems involving insufficient range, excessive cabin noise, fuel flow, avionics, fuselage heating, and more. This is not to say that they didn't try, using quick fixes as well as legal and illegal methods, to leap those technological hurdles. But as the author of this well-researched book argues, the Soviets should have engaged in long-range research in an effort to overcome recurring problems, rather than attempting to beat the West in the SST competition.

Reports of the death of the Soviet SST might be premature, however: the Soviets tested a hydrogen-powered aircraft last year, and intelligence sources report that a Tu-144 has made a few covert flights this year. In addition, at this year's Paris Airshow, the Soviet Sukhoi design bureau announced that it has joined up with Gulfstream Aerospace of Georgia to build a small supersonic business jet. One hopes that present-day Soviet technocrats and Gulfstream executives will read this book and absorb its lessons.

—Seth Arenstein is the editor of Soviet Aerospace, *a journal that monitors Soviet military and space developments.*

***In the Cockpit** by Easton Press Video (1-800-367-4534). Six 60-minute VHS video cassettes in library case. $154.50, or six monthly payments of $25.75 (15-day refund guarantee).*

I'm 62. I'll never fly a fighter again. When I ordered the six-videotape series "In the Cockpit," I had hoped to relive some of the sensational moments of my fighter pilot days and experience what it would be like to fly a jet fighter. I knew that some things

would have to be left to my imagination—the kick of the afterburners, the tug of the G-forces, the odor of kerosene—but I considered the cockpit's sights and sounds to be worth the expense.

Judging from the series' name, I expected to see the airplanes from a pilot's-eye view: the instrument panels and controls in front of me, the drama of a ground attack far below, the sky spinning during aerobatics or dogfights. These *were* shown, but only a small portion of "In the Cockpit" was actually filmed there. Despite the series' name, most views of the airplanes are taken from the ground, from aircraft carriers, or from another airplane.

After this initial disappointment, however, I was captivated by the professional production and broad content of these tapes. The images are sharp, the script detailed, the narration clear, and the sound superb.

One strong point is that the collection covers many aircraft from different nations, rather than concentrating on U.S. aircraft alone. Many of the foreign aircraft shown were new to me and I enjoyed learning about them. A wealth of other detail, including scenes and descriptions of many airborne weapons and aircraft specifications and missions, should satisfy those more familiar with the aircraft.

"Fly Low, Hit Hard" takes you to Vietnam with the American A-4 Skyhawk, F-4 Phantom, and A-7 Corsair. The A-10 Thunderbolt, Israeli Kfir, British-French Jaguar, and British-German-Italian Tornado are also shown. "Target Tank" demonstrates the awesome power of tank-killing helicopters used in Southeast Asia and by European NATO forces. "Eagles in the Sky" describes in detail the older F-86 Sabre and F-100 Super Sabre, as well as the F-14 Tomcat, F-15 Eagle, F-16 Falcon, the French Mirage 2000, and the Swedish Viggen. "Red Star" focuses entirely on Soviet combat aircraft, including helicopters used in Afghanistan combat. And "Spies in the Skies" describes reconnaissance aircraft: Lockheed's famous U-2 and SR-71 Blackbird, the RF-4 Phantom II, AWACS, and Hawkeye.

As a former carrier-based pilot, I was most disappointed by "Flat Tops," which features carrier-based catapult launches and recoveries and shows carriers taking on North Vietnamese targets. A nine-minute addition to this tape includes footage of the January 4, 1989 downing of two Libyan MiG-23s by two F-14s. However, not a single takeoff or catapult shot is shown from the most exciting of vantage points—the pilot's perspective, and only about 25 seconds of the 55-minute tape show carrier

approaches from this viewpoint.

Those who buy the series expecting to experience the thrills of being "in the cockpit" will likely share my disappointment. Overall, though, I have to give a high rating to these videos for their quality and content. If you are interested in combat aircraft, this set of videos provides enough material for repeated viewings and would serve as an excellent reference.

—Fred Blechman, a freelance writer, flew Navy F4U Corsairs with the VF-14 squadron in the early 1950s.

***The Great Air Race of 1924**, an hour-long episode of the PBS television series* The American Experience. *Debuts on October 3.*

In 1924 four single-engine biplanes—the *Seattle, New Orleans, Boston,* and *Chicago*— left Seattle in an attempt to fly around the world. At the time, the Pacific had never been crossed by air. Nonetheless, the two-man crews of these radio-less airplanes planned to cross both the Atlantic and Pacific oceans during a flight that promised to be neither easy nor, in the open-cockpit airplanes, comfortable. One hundred seventy-five days, 26,000 miles, and 17 engines later, two of the airplanes returned to Seattle: the globe had been circled by air for the first time.

The world press dubbed the eight Army crew members "the Magellans of the Air." Ferdinand Magellan had died before he finished his around-the-world voyage; luckily, none of his aerial namesakes perished. The *Seattle* crew came close, though, when they crashed into an Alaskan mountain, and the *Boston* crew had to be rescued at sea after their airplane was forced down over the North Atlantic.

"The Great Air Race of 1924" recounts the World Cruisers' flight with a mixture of newsreel footage, still photos, and talking heads. It doesn't stray from standard television documentary form, but there is still much to interest aviation and history buffs. Footage from the well-documented adventure ranges from preflight training (and hobnobbing with Hollywood stars) to the ecstatic welcome the fliers received in Japan (despite anger over U.S. legislation limiting Japanese immigration to the United States) to the loss of the *Boston* so close to the end of the journey.

However, the "race" of the title, which refers to other global attempts by French, British, and Portuguese fliers, seems more a conceit to create dramatic tension than an accurate description of the competition. The Americans, after all, were financed by the Army, which had hoped to drum up support for its aviation program, and had some of the best airplanes of the time (designed especially for the flight by a young Donald Douglas), as well as access to fuel dumps, supply depots, even rescue ships around the world. All that preparation still didn't prevent the crew of the *Seattle* from having to make an arduous trek from their crash site through the Alaskan wilderness before being rescued. After that adventure, the rest of the journey seems almost anticlimactic.

Sixty-five years after its crews were received as heroes in Seattle, the world flight has been largely forgotten. If nothing else, "The Great Air Race of 1924" will remind viewers of this epic flight, one that made the world a slightly smaller place.

—Tom Huntington is the managing editor of Air & Space/Smithsonian.

Credits

The Far-Right Stuff. Alex Heard is a Washington, D.C. writer.

The Flight of the Bumblebee. Following his tours of duty, Louis R. Purnell held a variety of jobs, including speech therapy instructor, librarian, and specialist at the National Museum of Natural History's paleobiology department. Prior to retiring in 1984, he was a spacecraft curator for the National Air and Space Museum, and he now lectures frequently about his experience as a Tuskegee airman.

The Tuskegee Experience. Theodore W. Robinson is a Tuskegee airman who graduated from B-25 pilot training on November 20, 1945. He has been a Federal Aviation Administration safety inspector for a number of years and is currently detailed to the National Air and Space Museum as a historian of black aviation.

To Mars and Beyond. A past president of the National Space Society, Ben Bova is the author of more than 70 nonfiction books and futuristic novels.

The Blue Collar Spacesuit. John Grossmann, a contributing editor for *Health*, has written for *Audubon*, *Hippocrates*, and *Esquire*. His article "Hover Story" covered human-powered helicopters for the June/July 1988 issue of *Air & Space/Smithsonian*.

The Strange Case of Carter Hall. Carl A. Posey's fourth novel of science and espionage, *Benchley's Chip*, will be published next year.

NASA's Data Deluge. Richard Wolkomir has written for *Discover*, *Playboy*, and *Natural History*.

The Burnelli Controversy. David Noland is a freelance writer and private pilot who lives in Mountainville, New York. His work has appeared in *Discover*, *Reader's Digest*, and *Sports Illustrated*.

The Last Flight of Professor Donaldson. Donald Dale Jackson is the author of *The Aeronauts*, a history of ballooning written for "The Epic of Flight" series published by Time-Life Books. For his 54th birthday, Jackson's wife gave him a ticket for a hot-air balloon ride.

Heroes. Alex Nelon pilots a corporate jet and teaches flying in Atlanta, Georgia.

From Slinkies to Space Horseshoes. Roy Kahn is a Washington, D.C.-based freelance writer.

"The Satellite Sky" Update/14

Launched but not in orbit

90 to 300 MILES

Cosmos 2028 USSR photo recon	6-16-89	down 7-6-89
Cosmos 2029 USSR photo recon	7-5-89	down 7-19-89
Cosmos 2030 USSR photo recon	7-12-89	down 7-29-89
Cosmos 2032 USSR photo recon	7-20-89	down 8-3-89
Resurs-F2 USSR earth sensors	6-27-89	down 7-11-89
*STS-28 USA research	8-8-89	down 8-13-89

Inoperative but still in orbit

300 to 630 MILES

Cosmos 1745

*STS-28 (space shuttle *Columbia*) is believed to have launched a military satellite.

Deletions

90 to 300 MILES

Cosmos 1870
down 7-29-89

Cosmos 2018
down 6-19-89

Cosmos 2020
down 7-15-89

Cosmos 2021
down 7-6-89

Cosmos 2025
down 6-15-89

Resurs-F
down 6-17-89

Corrections to last issue's Update

Cosmos 2004 orbits in the 630-1,250 mile band, not the 300-630 mile band. GPS-1 was launched from Cape Canaveral Air Force Station, not Vandenberg Air Force Base.

New launches

90 to 300 MILES

Cosmos 2027
6-89 PL

Cosmos 2031
7-89 TT

Cosmos 2033
7-89 TT

Cosmos 2035
8-89 PL

Resurs-F3
7-89 PL

Resurs-F4
8-89 PL

300 to 630 MILES

Nadezhda
7-89 PL

Cosmos 2034
7-89 PL

21,750 to 22,370 MILES

ADSP 1
6-89 CAC

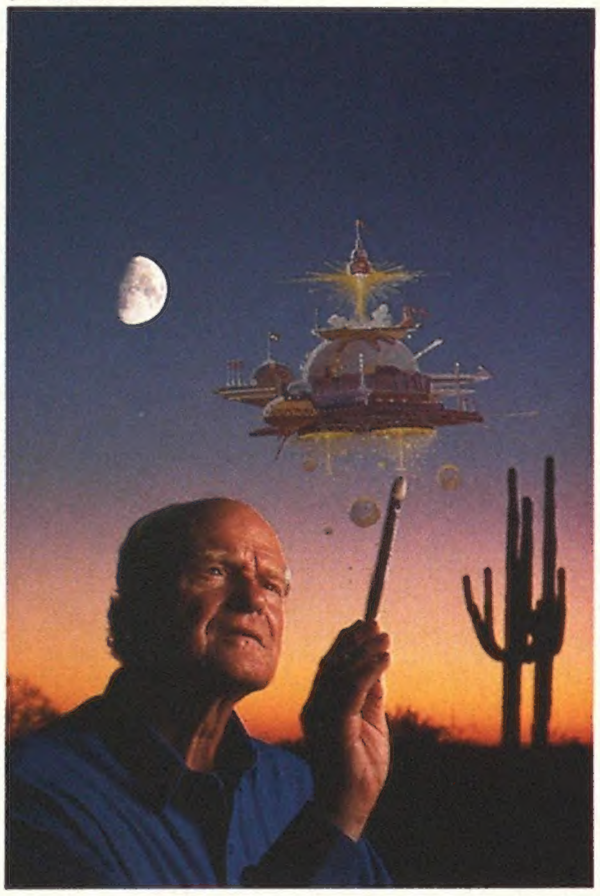
Olympus 1
7-89 KOU

Gorizont 18
7-89 TT

Raduga 24
6-89 TT

In the Wings...

JIM RICHARDSON



Future Visions—Space artist Robert McCall claims to be on good terms with the future. And why not? After all, he's a regular visitor there. "The things he does in some of his paintings," says astronaut Eugene Cernan, "are things that seem a little far out today, but are truly things that *will* happen some day."

Salyut Rescue—When the Soviet Union lost contact with its space station Salyut 7 in October 1984, it sent cosmonauts scrambling to prepare for a unique rescue mission in space.

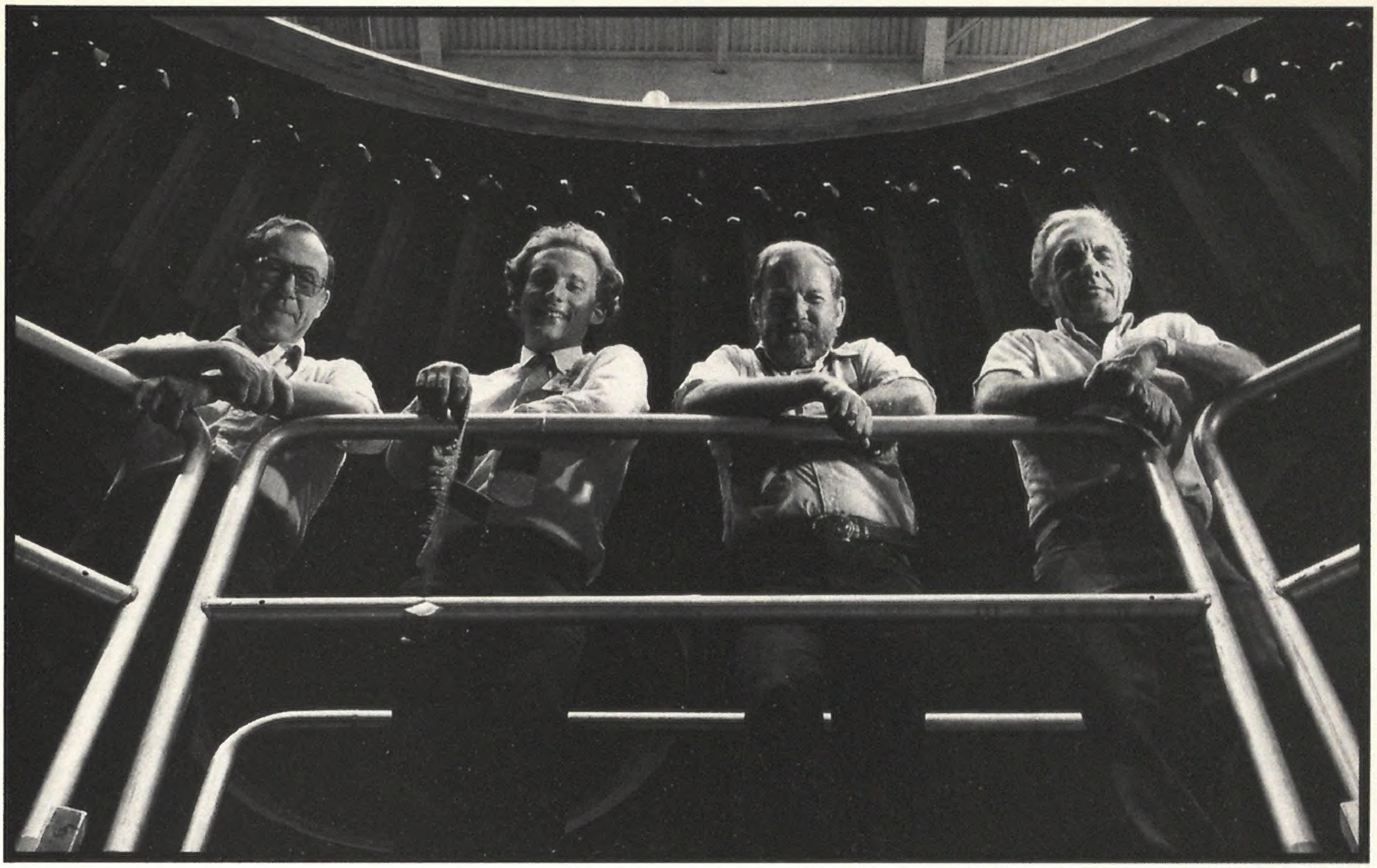
The Vultures of Davis-Monthan—There's gold in them thar airplanes—though less than there used to be. New circumstances are changing the once-lucrative aircraft salvage business.

Zero!—Three months before the Japanese attacked Pearl Harbor, *Aviation* magazine declared that their aircraft were "obsolete or obsolescent." The stunning success of the Japanese A6M2 Type 00—the Zero—quickly changed that tune: American aviators were soon being told "Never attempt to dogfight the Zero." The Japanese fighter was the hottest thing in the sky—and historians still argue over why it caught Allied air forces so flat-footed.

The Voyage of Magellan—Hidden beneath layers of clouds, Venus is still largely uncharted territory to Earth-bound scientists. A probe named Magellan may reveal some of its secrets. Armed with the latest in radar technology, this product of strict budgetary realities is on its way to peer beneath the clouds of our nearest planetary neighbor.

Flying at the Bottom of the World—Earth's southernmost airline is a small fleet of C-130s and UH-1N Huey helicopters that services American scientific missions in Antarctica. It flies over a land with two faces—one of unique beauty and another of implacable hostility. In such a climate the words "weather permitting" don't even need to be spoken.

ANN HAWTHORNE



"We use one of the largest vacuum chambers in the world to test our nose cones. The testing lets us see exactly what will happen when the cone is explosively separated to release a satellite into orbit.

But we needed a better way to control the nose cone during separation, to keep the cone from getting damaged or from causing any damage to the walls of the chamber.

Well, I climb mountains in my spare time. Crazy as it may seem, that's how I got the answer to our problem. I figured we could get the control by hooking up the kind of rip-stitch shock absorbers that climbers use to stop their falls.

The whole team pitched in and made the idea work. We count on each other. And that can be as exciting as mountain climbing."

—Chris Fuld, Space Systems Development, Manager Test Engineer (2nd from left) with Fred Eckhardt, Senior Engineer-Scientist (left), Dick Durant, Senior Engineer-Scientist (right), Bob Frenchick, Senior Engineer-Scientist (3rd from left)

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